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Aeronautical Engineering
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THIS YEAR'S AIR ESTIMATES

WHILE this issue of THE AEROPLANE is being printed and distributed, the debate on the Air Estimates will be taking place. Consequently we shall not be able to achieve much by commenting at length on the contents of the Memorandum prepared by the Secretary of State for Air, the Rt. Hon. George Ward, to accompany the Estimates proper. By the time that these words are read the debate will have taken place and we shall be able to add nothing helpful to the remarks which have already been made. Also the terms of agreement between ourselves and the United States regarding the siting of U.S. rocket bases in this country will have been discussed at length.

The White Paper (Cmnd. 366) "Supply of Ballistic Missiles by the United States to the United Kingdom" costs fourpence and, as this price might be expected to indicate, is a remarkably concise statement for a subject of such tremendous implication. There are 10 points of agreement in the Memorandum and each is couched in general terms so that there is no information about the sites or where they are to be or about the number of missiles. It is to be noted that the IRBMs are to be deployed at sites, only to be located in the United Kingdom, and in such conditions as may be agreed between both Governments. Ownership of the missiles and related equipment shall pass to the U.K. Government under established U.S. Mutual Assistance Program (*sic*) procedures as soon as the U.K. is able to man and operate the missiles. The U.S. Government is to provide the nuclear warheads which are to remain in full U.S. ownership, custody and control.

Among all the views, of which we may expect to read much, we shall be surprised to find any large body of opinion which either expresses surprise or presses for an inquiry into the fact that we have been forced to accept such extensive friendly help because of our own failure to develop rockets of the size required and in the necessary quantity. Such a lamentable feature in national planning would seem to deserve a full-scale investigation; but that is hardly likely to be forthcoming. One of the prices a country has to pay for a well-run security system is a public ignorance about armament affairs which prevents any lassitude in developing such equipment from being adequately castigated.

What time we are pressing on with top priority for an IRBM, supplies of the U.S.-built Thor will be coming into the American-operated bases in this country. While on the subject of guided weapons it is interesting to note the official admission that ultimately it is to the anti-missile weapon that we must look for defence against the long-range missiles. This possibility was explored and found to be fruitful in THE AEROPLANE quite a while back, on October 26, 1956, to be precise, when the official view was that no defence was practicable against rockets. Most people will not consider the prospect of an upper atmosphere filled with megaton rockets being chased and blown up by destroyer-rockets a particularly encouraging prospect, though it must be regarded as less bleak than a situation where no defensive action is possible.

We find ourselves in sympathy with the leader-writer in a recent issue of *The Times* who, writing under the heading "The Real Threat," considered that "our preparations should be directed towards limited wars and lesser conflicts, for which modern fighter aircraft are essential." He contended: "In the past we have designed fighters for the specialized task of defending Britain and, as Suez showed, only secondarily for other rôles. In the future we should reverse the order." He might have added the comment that fighters, designed for a rather more general rôle, could be expected to have a promising export potential.

However, fighters are not the only equipment needed to look after our overseas commitments. And it is in this especial context that we have been disappointed to note no specific reference to building up the equipment of Transport Command. Ever since the attack on the Suez Canal demonstrated the severe limitations imposed on our airborne mobility by lack of equipment we should have thought that there would have been powerful pressures brought to bear to ensure the provision of adequate air transport. The Memorandum notes that a full training and exercise programme has been carried out with the airborne forces of the Regular and Territorial Armies. It used to be a favourite jibe of the Founder Editor of THE AEROPLANE that only drunks and corpses were carried out; no doubt the Memorandum means that it was the Airborne Forces who performed or carried through the training and exercise programme.

How interesting to know how comprehensive such training is and, for instance, whether the airborne members of the Regular and Territorial Armies at the end of it had had as much experience of being dropped in operational conditions as those French airborne troops who were engaged in the Suez operation. We earnestly hope to learn that pressure was brought in the debate to make the Government think again about its military air transport equipment.

MATTERS OF MOMENT

About the New Company

LAST week—on February 19—the board of the Aircraft Manufacturing Company held its first meeting. This new company, as already reported, is to be capitalized with de Havilland (67½%), Hunting (22½%) and Fairey (10%) holdings and the initial capital, to cover the early stages in the work on the D.H.121 for British European Airways, will be £1 million.

The directors are: Chairman, Mr. W. E. Nixon (chairman, de Havilland Aircraft); deputy chairman, Mr. Richard Fairey (vice-chairman, Fairey Aviation); managing director, Mr. A. F. Burke (managing director, de Havilland Aircraft); Mr. C. P. M. Hunting (director, Hunting Aircraft and other Hunting Group companies), Mr. A. S. Kennedy (director, de Havilland Aircraft), Mr. F. E. N. St. Barbe (director, de Havilland Aircraft) and Mr. W. A. Summers (managing director, Hunting Aircraft).

At the first meeting the board confirmed the appointment of four executive teams of the three companies to be responsible for finance and administration, technical organization, production and marketing. So far as the latter is concerned, sales negotiations are reported to be in progress and the company states that technical sales teams had, at the time of the first meeting, already gone overseas. The company adds that "considerable progress has, in fact, already been made towards the finalizing of the specification and of design features" and in contract negotiations with B.E.A.

The registered office of the new company is that of de Havilland at Hatfield and the London office is Norwich House, 4 Dunraven Street, Park Lane, W.1—which is also that of the Hunting Group of companies.

Quiet, Cool Russian Engines

ONE of the most interesting points to be established in the course of the negotiations now going on with the Russians about the joint operations by B.E.A. and Aeroflot over the route between London and Moscow concerns the external noise level of the Tu-104. It has been said that this machine is notably noisy and indeed Mr. Watkinson, Minister of Transport and Civil Aviation, has been at pains to make clear his determination that the officials of his Ministry must be satisfied on this point before agreement for the Tu-104 to use L.A.P. is granted.

There is, in consequence, special interest attaching to some observations in the January issue of the American periodical *Fortune*. In that highly regarded business magazine, there is a most informative article devoted to a study of the achievements of the Curtiss-Wright Corporation and of its sixty-one-year-old president, Roy T. Hurley. Discussing the supply of jet engines to commercial operators he is quoted in that article as having said:—

". . . But we must come to quiet, cool engines in the U.S. for commercial use in the end. The Russians have them. That Russian transport that came here recently had a quiet, cool engine.' We know. We've had crews measuring decibel levels in every major U.S. airport. Those crews measured the noise when the Russian transport came into McGuire Air Force Base in New Jersey, and when it left. Those engines were quiet. The picture we took of the vital openings, and our subsequent calculations, indicate that the Russian engine was cool, too. . . ."

A Tu-104A transport carrying delegates to a U.N. conference in New York landed at McGuire A.F.B., New Jersey, on September 4 last year (THE AEROPLANE, September 13). See also page 282 of this issue.

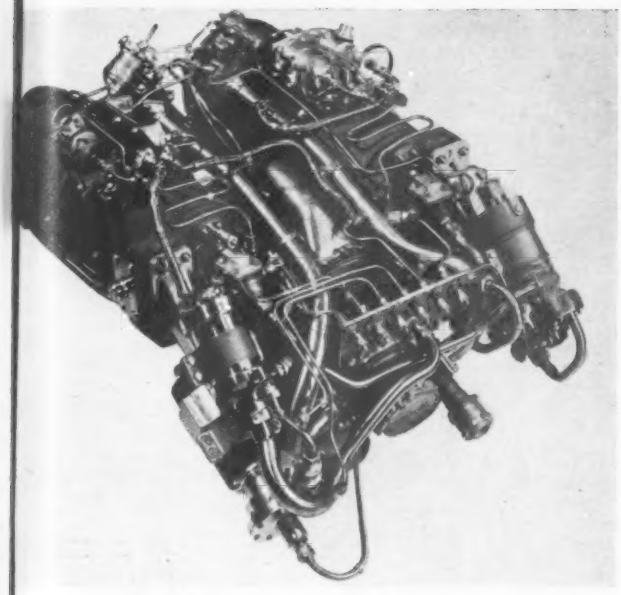
Rocket Power For the P.1B

ENGLISH ELECTRIC'S P.1B supersonic fighter is to be fitted with a Napier Double-Scorpion rocket motor for special operations. The Double-Scorpion and its high test peroxide oxidant tank are fitted into a ventral pack which can be attached to the underside of the P.1B fuselage. Fuel for the rocket motor is drawn from the aircraft's normal tanks. Several P.1Bs will take part in trials with the Double-Scorpion.

Designed and developed by D. Napier and Son, Ltd., the Double-Scorpion rocket motor has been extensively flight-tested in a Canberra which set up a World altitude record of 70,310 ft. last August. The Double-Scorpion is 33.75 in. long and 23 in. wide; it has twin barrels which can be fired together or separately depending on the thrust required. The motor can be repeatedly stopped and started at any altitude.

The rocket motor is an optional additional powerplant; it enables the P.1B to be operated either as a mixed-powerplant fighter or as a pure-jet fighter. The aircraft's two Rolls-Royce Avon turbojets and their after-burners give sufficient

NEW COMPANY.—The board of the newly formed Aircraft Manufacturing Company comprises, left to right, Mr. W. E. Nixon, chairman; Mr. Richard Fairey, deputy chairman; Mr. A. F. Burke, managing director; Mr. C. P. M. Hunting; Mr. A. S. Kennedy; Mr. F. E. N. St. Barbe; and Mr. W. A. Summers. On the immediate left is the company's London headquarters.



FIGHTER POWER-PACK.—A Napier Double-Scorpion HTP/kerosene twin-barrelled rocket engine of the type to be fitted in a ventral power-pack in a mixed-powerplant version of the English Electric P.1B.

thrust for normal operations without the need for additional rocket thrust.

This new rocket pack will enable the P.1B to climb very rapidly and will increase the altitude at which interceptions can be made. Rocket engines enable thrust to be boosted greatly; for short periods of increased thrust the weight of a rocket engine and fuel is less than the extra weight of a reheated turbojet plus fuel. With rocket boost, aircraft speed can be built up rapidly at medium altitude so that a very fast zoom climb can be made. Rocket power also gives the additional thrust necessary for effective manœuvring at very high altitude.

Endurance of the P.1B with its rocket pack will be greatly reduced. For normal operations a ventral fuel tank can be fitted in place of the rocket pack. Thus, in the mixed-powerplant rôle the P.1B will have three engines—two Avons and a Double-Scorpion—drawing on less fuel than is available for the two Avons of the P.1B with turbojet power alone. This suggests that additional under-wing tanks may be necessary for the mixed-powerplant P.1B if its flight endurance is not to be very short.

S.L.A.E. Proposals

THE Society of Licensed Aircraft Engineers has issued a policy statement about the future licensing of aircraft engineers. Copies have been sent to the Minister of Transport and Civil Aviation and to the chairman of the A.R.B.

The S.L.A.E. makes 10 proposals. These are:—

1. The aircraft maintenance engineer's licence should be regarded as a qualification and not solely as a means of airworthiness control.
2. Basic licences should be introduced in the "A" (airframe) and "B" (engine) categories in addition to the existing type licences in these categories.
3. Certification of rectification of defects should be carried out only by licensed aircraft engineers.
4. "A" and "C" licensed engineers should no longer be expected to have intimate knowledge of sealed components which are renewed and replaced by serviceable units.
5. The type licensing system should be made universally applicable to all aircraft.
6. "X" category licences for electrics and instruments should be divided into maintenance and overhaul parts. An electronics category should be introduced and ancillary categories of licence re-designated.
7. A.R.B. proposals for master licences should be integrated with those of the S.L.A.E. for basic licences.
8. In the gaining and extension of licences additional privileges should be granted to corporate members of the S.L.A.E.
9. Type endorsements should not be removed from licences when aircraft and engines are taken off the British civil register.
10. Independent operators should introduce apprentice, basic and type training schemes similar to those of the national airline corporations.

London U.A.S. Dinner

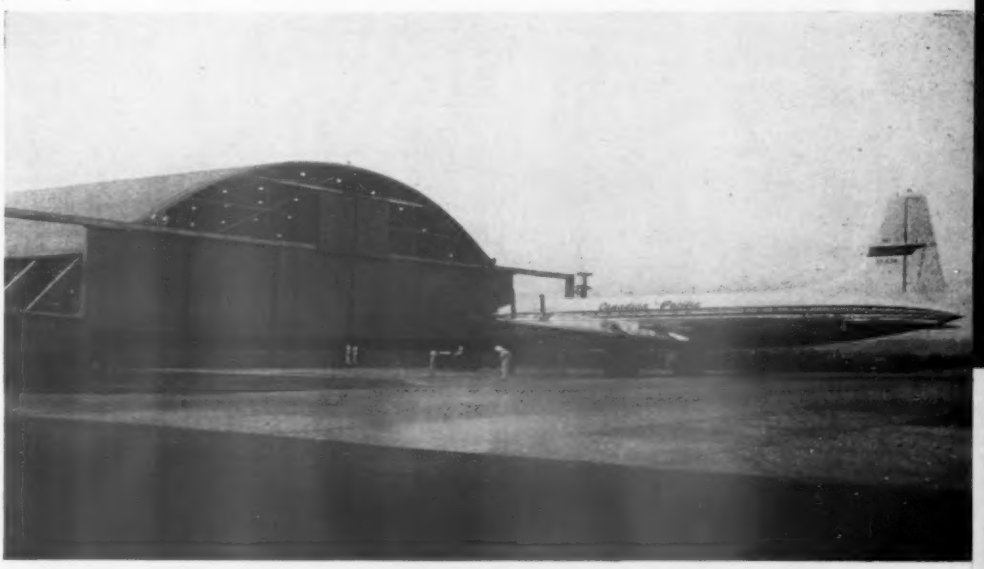
A DISTINGUISHED gathering including the Secretary of State for Air, the Chief of the Air Staff, and senior Service officers were present at the annual dinner of the University of London Air Squadron on February 21. Dr. J. F. Lockwood, the Vice-Chancellor, was among University personalities at what was a memorable evening, which also marked the last such occasion that the lady members of the Squadron's Fighter Control Flight would attend.

Among the other guests present were Air Chief Marshal Sir Walter Dawson, who, until recently, was the Inspector-General of the R.A.F.; the first adjutant of the Squadron, Air Marshal Sir Douglas Macfadyen, A.O.C.-in-C., Home Command; Air Marshal Sir John Whitley, Air Member for Personnel; Air Marshal Sir Edward Hudleston, Vice-Chief of the Air Staff, and Air Vice-Marshal F. H. M. Maynard, who formed the Squadron in 1927. The R.A.F. Technical College, Henlow, which has seven cadets in the Squadron, was represented by the Commandant, Air Commodore T. U. C. Shirley.

WING COMMANDER N. CAMERON, the C.O., summarized some of the outstanding events since the 1957 dinner, including the Inspector-General's investigation, the winning of the Hack Trophy for the first time, and the assurance of the Squadron's

CONTENTS

ATTERS OF MOMENT ....274 and 299
EWS ITEMS .....278 and 300
R TRANSPORT 280
E PRIME MINISTER'S TOUR....283
R-AWAY FRONTIERS—I, by John Fricker 284
E FIGHTING SERVICES 287
RTS FOR TODAY AND TOMORROW 289
E ECONOMIC VALUE OF WEIGHT SAVING, by J. C. Dykes..294
IVATE FLYING AND GLIDING..301
RRESPONDENCE 302
REN'S WROUNDABOUT 303
OTES AND EVENTS 304



TWO NEWCOMERS.—The first Canadian Pacific Britannia 314 was in Vancouver last week-end for the opening ceremony of the new Britannia hangar—both of which are seen here. A note appears on page 280.

Photograph copyright "The Aeroplane"

existence for a further period of five years. Although certain changes in shape—in fact the loss of 35 exciting shapes—had taken place with the disbandment of the Fighter Control Flight.

DR. LOCKWOOD replying to the toast, reminded his listeners of the Queen Mother's tribute to the Squadron—" simple but effective discipline "—after one of her inspections, and said that the C.O.'s recruiting drive had produced 160 candidates for the 23 places available. Regretting the disappearance of the Fighter Control Flight, Dr. Lockwood reported that eight members took regular commissions with the R.A.F. last year and a further eight were entering the regular Air Force this year.

THE RT. HON. GEORGE WARD, Secretary of State for Air, proposed the toast to the Squadron and emphasized that the university air squadrons were one of the best possible sources of officer material in the country. It was not the squadron's job just to make people air-minded, but to show that the R.A.F. offers a career better than many in civil life. Referring to the vital rôle of the R.A.F. of supplying the nuclear-bomber deterrent, the Secretary of State said that the Service does not stand or fall by it alone. With the largest possible Air Force that the limitations of money and manpower could allow, and the country's commitments in various regional pacts, the British airman has never before had such an important number of tasks in peace time.

MR. P. J. W. CREIGH, of the Imperial College of Science and Technology, replied for the Squadron with some light-hearted stories and comments, and the annual prizes were presented by by the Secretary of State. —P.R.R.

MAIN POINTS FROM THE AIR ESTIMATES

● The net total of Air Estimates for 1958-59 is £467,050,000 (net total for 1957-58 was £487,650,000). The total before deducting the Deutschmark costs of the Second Tactical Air Force in Germany is £474,550,000. About £11,000,000 is for improvements in pay.

● Provision for petrol and oil is reduced by £2,500,000. Gross provision for aircraft and equipment is £17,300,000 less than in 1957-58.

● Gross provision for works is £19,570,000 less than last year's estimate. We expect to recover about £16,000,000 from the United States Government for costs incurred on their behalf.

● The strength of the Royal Air Force on April 1 next will be 193,000 compared with 228,000 on April 1, 1957. By April 1, 1959, it should be down to 174,000. These figures include women and boys.

● Last year, 10 operational stations at home and in Germany were closed, in 1958-59 we plan to close four more. Several formation headquarters at home and overseas are being abolished.

● Our manpower target from the end of 1962 is a force of 135,000 regular officers and men and 13,000 women and boys. The average rate of recruiting, based on the last nine months, would be more than sufficient to maintain a force of this size but would not build it up quite quickly enough. We should be about 10% short of our target by 1962.

● The entry of cadets to Cranwell has been maintained at a satisfactory level and is now benefiting from the flow of cadets from the scholarship scheme introduced in 1953. There was, however, some decline in aircrew recruiting. In particular, we need more navigators and air electronics officers. The entry of technical branch cadets to Henlow has also been satisfactory.

● We have achieved our target for the year for apprentices and boy entrants (except for administrative apprentices). The Air Training Corps is providing a large proportion of our new recruits.

● We need more recruits for the Women's Royal Air Force.

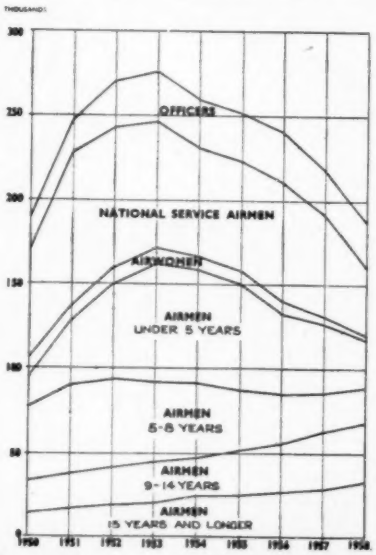
● The build-up of the Victor and Vulcan force, together with the success of the United Kingdom megaton weapon development programme, has greatly increased our deterrent power. Megaton bombs were successfully dropped on target from Bomber Command Valiants in the 1957 series of tests. The Royal Air Force also took part in atomic tests at Maralinga.

● The continued effectiveness of the deterrent will be assured by the Mark II Victors and Vulcans, which are now on order. Powered bombs of considerable range are being developed. A British ballistic missile is also being developed on the highest priority.

● Flight-refuelling equipment is being developed and successful trials have been carried out involving the transfer of fuel between Valiants. There will next be trials with the Vulcan and the Victor in the receiver rôle.

● Our smaller force of fighters will be needed to deal with manned aircraft, especially at longer range, to prevent reconnaissance, to investigate unidentified movements and to deal with the stand-off bomber and jammer. The P.1 and its associated air-to-air guided weapon are being developed for this purpose.

● Firing trials of Bloodhound are going ahead well at Woomera. Trials of a complete weapons system should start soon at the first R.A.F. guided weapons station at North Coates. An operational deployment will follow. There will also be trials of Thunderbird this year.



Long-term engagements are steadily rising.

● We can expect Fighter Command to meet a bomber attack at a greater distance from our shores and with a greater proportion of our fighter force both by day and night.

● The Royal Observer Corps has still a vital part to play. On top of its traditional rôle, it is responsible for reporting and tracking radio-active " fall-out " for the Services and for the National Warning System. More recruits are urgently needed.

● The Canberras in the Second Tactical Air Force and in Bomber Command are being given a nuclear capacity. Re-equipment with later types of aircraft is also adding to the strength of these squadrons. R.A.F. radar stations in the Second Tactical Air Force are a major element in the European radar chain.

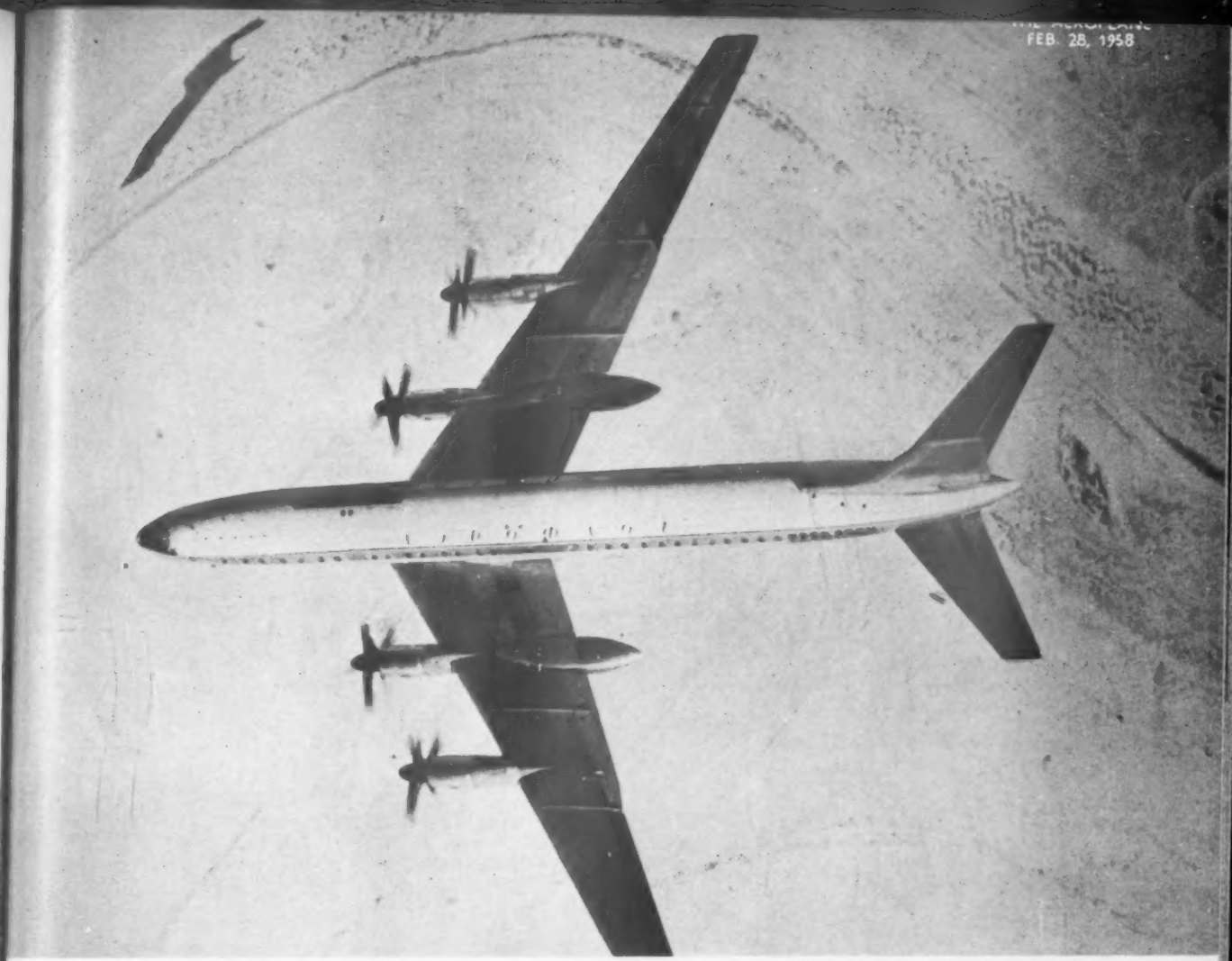
● Headquarters, British Forces, Arabian Peninsula, will become a separate Command, responsible direct to London, from April 1 next. The Commander, who will also be the Air Officer Commanding, Aden, will control all British land and air forces in the Arabian Peninsula, Persian Gulf and British Somaliland as well as Royal Air Force units in East Africa and any naval forces allotted to the Persian Gulf. At the same date Air Headquarters, Levant, which is in Cyprus, will be abolished and its tasks taken over by Headquarters, Middle East Air Force.

● The Agreement between the United Kingdom and the Federation of Malaya provides for the maintenance of Royal Air Force units in Malaya and the use of bases there for the external defence of Malaya and the fulfilment of Commonwealth and international obligations. Under the terms of the Agreement, the Royal Air Force is now helping to develop a Malayan Air Force.

● The staging post at Gan in the Maldive Islands, now being built, is already being used by medium-range aircraft taking supplies to the airfield.

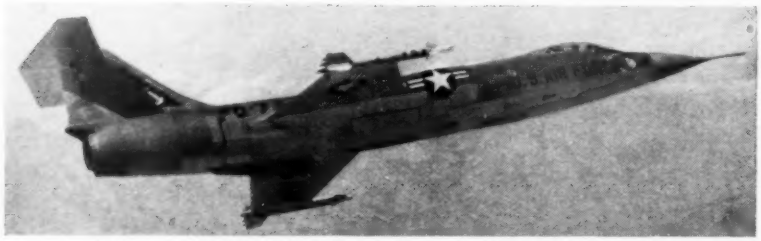
● Army airborne forces have all been converted to the Beverley and a full training and exercise programme has been carried out with airborne forces of the Regular Army and Territorial Army.

● The major accident rate showed a significant improvement on the 1956 figure and reached a point well below any previous record. The fatal accident rate was virtually the same as in 1956, itself the lowest rate for over 20 years. There was a marked improvement in the major accident rate for jet-engined aircraft.



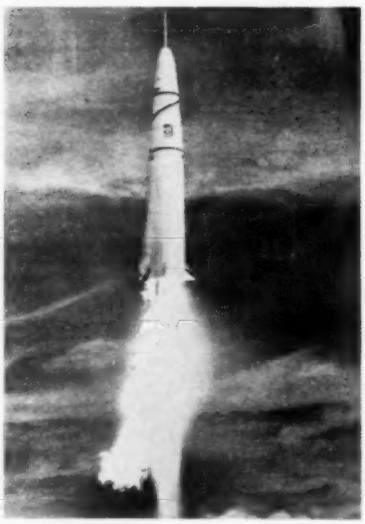
WORLD'S LARGEST TURBINE TRANSPORT.—These pictures of the Tupolev Tu-114, taken during flight trials which have recently started, are the first adequate to give a measure of the shape and size of this giant transport with a maximum take-off weight of 413,900 lb. The powerplants are Kuznetsov NK-012M or -002K turboprops giving 12,000 s.h.p. each. Dimensions, weights and performance figures for the Tu-114 were published in last week's issue (p. 230) with (p. 231) drawings of representative interior layouts.

News of Aircraft, Engines and Missiles



MISSILE MOUNT.—Sidewinder infra-red guided missiles are mounted on Lockheed F-104A Starfighters. The Starfighter also has a six-barrel Vulcan cannon on the port side of the nose. A Starfighter recently flew at supersonic speed for more than 1 hour.

MISSILE BASES.—Most of the terms of the Anglo-American agreement for the establishment of missile bases in the U.K. were presented to the House of Commons by the Minister of Defence, Mr. Duncan Sandys, on February 24. At the time of going to press it was believed that four bases, each of which will be equipped to handle about 15 intermediate range rockets, are to be established. The U.K. will pay for the construction of the bases and the United States will pay all, or a large part, of the cost of the "hardware."



MISSILE FOR BRITAIN.—The Douglas Thor IRBM is to be supplied to the United Kingdom. Here one is seen being launched at the missile test centre at Cape Canaveral, Florida.

FAST FLIGHT.—An English Electric Canberra has flown the 2,058 miles between Washington, D.C., and Caracas, Venezuela, in 4 hr. 11 min.

ATLAS AND POLARIS PLANS.—America's Assistant Secretary of Defence has said that the 5,000-mile Atlas ICBM is expected to be "ready for regular troops" by the end of next year. He said too that the U.S. Navy's IRBM Polaris was also intended for land-based launching.

PROPULSION FOR POLARIS.—The Aerojet-General Corpn. has developed very large solid-fuel rocket motors for the U.S. Navy's Polaris ballistic missile. The Polaris will carry a nuclear warhead over a range of about 1,700 miles. It will be launched from both surface ships and submarines. Successful test firings of this missile have been made recently.

ATOMIC CONTRACT.—A design contract for an atomic rocket engine has been awarded to North American's Rocketdyne Division by the U.S.A.F. This is an extension of preliminary work already done by Rocketdyne in this direction.

HUMPLESS YAK.—The Yakovlev Yak-20 is a new light aircraft developed for DOSAAF from the earlier Yak-18U, and powered by a 200-b.h.p. radial engine in an NACA-type cowling, without the streamlined blisters of the former series.

RASCAL FIRED.—First firing of a Bell Rascal air-to-ground missile from a Stratojet bomber was accomplished on February 17. Rascal is a "stand-off bomb" with a range of about 100 miles; it has an atomic warhead and is powered by three liquid-propellent rocket engines.

BURMA DELIVERY.—Three Hunting Provosts are being flown to Burma for the Burmese Air Force. The flight, organized by Fieldair, Ltd., involves 17 stops and 48 hours' flying over a distance of 7,300 miles.

MISSILE EXPORT.—According to reports from Sweden that country is to buy £7 million worth of British anti-aircraft guided missiles, said to be Bristol Bloodhounds and English Electric Thunderbirds.

RUSSIAN LIGHT JET.—At the recent annual meeting of DOSAAF, the Soviet flying club organization, it was disclosed that new flying equipment is to be issued next year, thus making Russia the first country in the World to use light-weight jets for popular flying. The new aircraft will be MiG-105s, which apparently resemble scaled-down fighters, with tandem two-seat cockpits, and are powered by a small engine of 1,100-lb. thrust. The MiG-105 is expected to fly later this year, and production of these aircraft is scheduled for 1959.

MISSILE RANGE.—A new American missile test centre is to be established on the Californian coast so that ICBMs can be fired "at least" 5,000 miles over the Pacific. It will be at Point Mugu, at the U.S. Navy's present missile test centre, 35 miles north-west of Los Angeles.

SAVING WEIGHT.—In this issue we publish an article that is worthy of close study. It deals with the all-important subject of weight saving in civil transport aircraft and has special reference to the advantages to be gained by using titanium nuts and bolts instead of steel ones. At the end of the article weight savings for three aircraft types are summarized. Readers may notice, however, that inadvertently the same summary table appears also under Table 4 on page 297, in which context it does not make its point as clear as it should.

AMPHIBIOUS VTOL.—Fitted with inflatable floats, a Vertol 44 takes off from the Delaware river. This equipment is to be used on the Vertols of New York Airways.

COLEOPTERE COMING. — The S.N.E.C.M.A. Atar Volant P.3 (enclosed cabin) VTOL aircraft, now being tested at Melun-Villaroche, will be followed by the Coleoptere C.450 being built by S.N.C.A.N. The C.450 is due for completion within a few months.

NEW MYSTERE.—The first flight of the Dassault Super Mystère B.4 was on February 9 at Melun-Villaroche. The B.4. has a S.N.E.C.M.A. Atar 9 turbojet which has an afterburning thrust of 13,230 lb.

COMET ENDURANCE.—During its Avon engine development flying, a B.O.A.C. Comet 2E stayed in the air for 8 hr. 6 min. on February 16-17, covering a distance of about 3,500 miles in a low-speed cruise flight over England and Europe. After landing there were still 900 gallons of fuel in the tanks.

NORD A.O.P.—Flight testing of the Nord 3400 (240-b.h.p. Potez 4D.30 engine) is nearly complete.

HELP FOR CARAVELLES.—The French Government has decided to grant a loan of £4,170,000 to Sud-Aviation to help them in speeding up the production of the first group of 50 Caravelles. A rate of four a month is planned by the end of 1958.

PARACHUTE CONTESTS. — The World Parachuting Championships, organized by the Czechoslovak Aero Club, will be held at Bratislava from August 1 to 16.

CANADIAN CHOICE. — The Fairchild J83 lightweight turbojet has been selected to power the Canadian CL-41 basic trainer. The J83 gives a static thrust for take-off of about 2,000 lb. and weighs about 300 lb.

MEGAPOUND ROCKET.—According to reports from America, the U.S.A.F.'s rocket team is working on a rocket engine capable of developing a thrust of 1,000,000 lb. It is said to have a single combustion chamber.

Commercial Aviation Affairs

LONDON-PARIS FREIGHT.—Skyways are starting, on April 8, a new air freight service between London and Paris in which consignments will reach Paris (or London) in less than 24 hours and at a rate cheaper than that for express rail and boat. The freight is flown between Lympne and Beauvais.

Austrian Airlines —insignia on left— now have their first Fred Olsen Viscount.

WESTWARD CARGO.—A through freight service from New York to points in Australia and New Zealand is now being offered by B.O.A.C. and Qantas.

AUSTRIAN CHARTER COMPANY.—Aero-Transport of Vienna, who operate a D.H. Dove, are buying a Viking from Lufttransportunion, of Germany, and another from Eagle Aviation. The latter will be fitted with Eagle's special freight doors. Aero-Transport has a co-operative arrangement with Lufttransportunion and another such arrangement is, we understand, being considered with Eagle Airways.

DEUX PONTS TOUR.—The Breguet Deux Ponts landed at Orly Airport, Paris, on February 19 after its 30-day demonstration tour in South America. In all it had covered about 25,000 miles.

FREIGHT INCREASE. — In 1957 Swissair achieved a 33% increase in freight traffic in relation to the 1956 figure. The tonne-mile total was, in fact, slightly more than that for all the six years, 1948-1953. Swissair has a DC-6A freighter on order for introduction in the autumn of 1958.

SELCAL ON TRIAL.—During this year a series of procedural trials of Selcal will be started over the North Atlantic. Selcal, which is in regular use in North American and Pacific areas, is, more fully, a selective calling system by which aircraft crews are alerted only when messages are to be passed, thus avoiding the necessity for continuous listening-out.

THE END OF CROYDON.—In a written answer in the House on February 20, the Minister of Transport and Civil Aviation said that it was planned to close Croydon Airport at the end of the summer season.

TOKYO CHANGE.—According to latest reports from Japan, the U.S.A.F. is to terminate its 13-year-long tenancy of Tokyo International Airport by the end of June. M.A.T.S. facilities will be moved to Tachikawa air base.

C.P.A. RADAR.—The Britannia 314s for Canadian Pacific Airlines are being fitted with the Bendix RDR-1 weather and terrain-mapping radar.

LUFTHANSA'S CREWS.—Of the 113 pilots flying for Lufthansa only 27 are now non-German; these are, however, flight captains. At the Lufthansa training school in Bremen 13 flying instructors are now employed.

Military Aviation Affairs

FREIGHTER'S FERN. — This Bristol Freighter Mk. 31 of No. 41 Sqn. R.N.Z.A.F. is the first aircraft to show the new fern-leaf marking adopted last year by New Zealand. No. 41 Sqn. operates in Singapore and Malaya.

R.A.F. ANNIVERSARY.—The 1958 "Battle of Britain" Week will be observed from September 15 to 21, and the R.A.F. "At Home" day will be Saturday, September 20. Last year, 1,079,630 people attended R.A.F. "At Home" displays at 27 stations.

R.A.F. CATERING.—Formed in 1949, the Deputy Directorate of Catering has been raised to the status of Directorate within the Directorate-General of Equipment. Its first Director is Gp. Capt. W. H. Canniford, head of the old Deputy Directorate since its inception nine years ago.

H.M.A.S. "MELBOURNE." — The Australian carrier "Melbourne" is to visit Pearl Harbour in June to take part in advanced anti-submarine exercises with the U.S. Pacific Fleet. Her air group will consist of 12 Gannets and eight Sea Venoms.

NEW GERMAN EQUIPMENT?—A delegation of the West German Air Force headed by Lt.-Gen. J. Kammhuber met executives of the Convair Division of the General Dynamics Corpn. at San Diego last week-end to discuss a new executive aircraft and air-defence problems. West Germany has been evaluating two Convair all-weather interceptors, the F-102A and the F-106.

STAFF COLLEGE AWARD.—The Brooke-Popham Memorial Trophy, competed for annually by officers taking the R.A.F. Staff College course at Bracknell, has been won for 1957 by Sqn. Ldr. I. D. Bolton, D.F.C. The trophy is awarded to the officer submitting the best essay on a selected subject of topical Service interest.

ROTARY SERVICE.—Six Sikorsky S-55s have been purchased by the Mexican Navy for coast guard and air/sea rescue duties. They will be based at Tampico, on the Gulf of Mexico, and in Manzanilla, on the Pacific Coast.

MORE NEWS ITEMS ARE ON PAGE 300

AIR TRANSPORT

Vancouver to London

THE first Bristol Britannia 314 of six ordered by Canadian Pacific flew non-stop from Vancouver to London Airport on February 23/24, and was the first commercial aircraft to do so. With no more than a 10 m.p.h. advantage from winds on the 4,800-mile flight, the Britannia completed the journey in three minutes under 14 hours at an average speed of 345 m.p.h.

This flight ended the second visit to Canada of the Britannia CF-CZA, which first flew on January 11 and will be handed over to the airline in about two weeks' time for a period of crew training at Bristol before being delivered to Canada permanently. It flew out to Vancouver, via Montreal, on February 20, to be present at the opening of the new $1.4 million Britannia hangar. The opening ceremony was performed by Mr. N. R. Crump, president of Canadian Pacific Railway, in the presence of several thousand guests and C.P.A.L. employees and their families.

Among the passengers aboard the Britannia on its return flight were Mr. P. G. Masefield, managing director of Bristol Aircraft, Ltd., Mr. R. E. Harvey, director and general manager of Short Bros. and Harland (who built this particular Britannia) and Mr. R. J. Reynolds, president of Bristol Aero Engines (Western), Ltd. The flight was commanded by Mr. Walter Gibb, Bristol's chief test pilot, with a C.P.A.L. crew. A fuller account of the flight, by a member of THE AEROPLANE staff who was also on board, will appear in our next issue.

Tidying up Europe's Airspace

THE fourth ICAO European-Mediterranean Air Navigation meeting—one of the most vital of the regional series—completed a three-week session at Geneva last week-end.

Airways for the upper and lower airspace (above and below 20,000 ft.) were duly considered. A basic plan was developed for the new route-network in the upper airspace for jet aircraft and it was agreed that this plan should be gradually introduced as the need arises and that it should be reviewed as experience with jet aircraft increases.

In developing the basic concept for the control of jet aircraft in this upper airspace, it was apparent that it would be necessary to co-ordinate civil and military operations in the region. The airspace available could no longer allow for the separation of these operations. It was therefore recommended that *all* operations in the upper airspace should be co-ordinated and controlled.

To make such control effective, two possible systems were recommended. These differed only in so far as they envisaged either a fixed airways network, or a flexible system of "predetermined routes" which could be adjusted according to meteorological and traffic conditions and military operations.

It was also recommended that the lower airways network should be set up fully by the middle of 1960, and that the upper airspace system should be introduced gradually and be completed by the end of 1961.

Of runway lengths required for the new turbojet aircraft, the meeting marked the first occasion on which sufficient data were available to estimate the approximate runway lengths required for planning purposes at each aerodrome in the region.

The meeting found that, generally, the network of meteorological stations was satisfactory, although it was considered that improvements were necessary in the volume of information available at midnight. The introduction of turbojet aircraft meant that more than normal attention would need to be paid to the upper-air observation network. It was agreed that rather than increasing the density of the observational network, it would be of greater value to increase the frequency of observations at existing stations. Accordingly, the meeting recommended that four daily observations be made at 56 stations.

The meeting also established a detailed plan for the exchange of actual weather information at aerodromes, of aerodrome forecasts and of significant en-route weather information. Regular observations are to be made throughout the Continent and the British Isles at half-hourly intervals, rather than, as at present, at hourly intervals. This weather information would be disseminated over distances up to about 1,000 miles.

Note was taken of the requirements for the measurement and forecasting of the air temperature over runways. In aid of landing attempts under marginal weather conditions, it was agreed that "runway visual range" methods would be standardized at all aerodromes equipped with precision approach systems.

Eagle to Bermuda

SUBJECT to final approval by the President of the U.S., Eagle Airways (Bermuda) will start services between New York and Bermuda on May 1 with an initial frequency of once daily.

Within the terms of the Anglo-U.S. Air Agreement Eagle have been designated by the U.K. Government to serve this route and, within the terms of the Canadian Air Agreement, other routes between Canada and Bermuda. The Bermuda Government have authorized the operation of such services for 10 years. IATA (of which Eagle Airways is a member) fares will apply. The C.A.B. has heard the case for a foreign carrier and has recommended the proposed services.

Services will be started using Viscount 800 Series aircraft laid out with a mixed-class, first and tourist, interior arrangement. The actual aircraft to be used will depend on arrangements made between now and the date of the opening service—but it is possible that a start may be made with a Viscount 805, of which Eagle now have one, with another due shortly.

Eagle have opened offices in New York at 51-53 Vanderbilt Avenue, in the premises originally occupied by Colonial Airlines, an earlier Bermuda operator.

TURBOPROP GIANT.—The Tu-114—seen here at Vnukovo Airport, Moscow, with No. 2 powerplant being started—certainly is a mighty affair. But, as the figures in last week's issue (p. 230) showed, it is also very much a "hot" affair, with its wing loading of 137 lb./sq. ft. (against 101 lb./sq. ft. for the intercontinental Boeing 707), its landing speed of 127 m.p.h. and its maximum-weight take-off distance of 9,350 ft. over the screen.

Developed Old-timer

ALTHOUGH familiar enough in the Americas, the C-46, or Curtiss Commando, has not so far been often seen in Europe. Now that Fred Olsen Flyselskap of Oslo, Norway, have two much-developed C-46Rs, with another on the way, for general charter use, we may see rather more of the type. One of these C-46Rs was, in fact, at Southend Airport last week.

The C-46R is a very much modified, developed and re-equipped aircraft in relation to the original Curtiss-Wright type. At its high permissible gross weight of 49,900 lb. and with a maximum payload of about 11,000 lb. in its passenger-carrying form (or about 12,000 lb. in freighter form) it is quite a work-horse and is comparable in general performance with the DC-4.

A great many changes have been made, through various marks up to the 46R, since the earlier versions. The flying-control boosters have, for instance, been deleted and replaced by a spring-tab system and the many minor but important modifications include changes in the fire-extinguishing and other essential systems. The C-46R has Pratt & Whitney R.2800-34 engines of 2,100 h.p. each and requires (at sea level and in I.S.A. conditions) a field length of only 5,400 ft. when meeting full transport category requirements at maximum weight. Its normal top cruising speed is a little less than 190 knots.

Fred Olsen's aircraft can be laid out as 50-seaters—with six rows of five-abreast seats and five of four-abreast seats—but will probably fly more often as 44-seaters, with 11 four-abreast rows. The seats are Payloaders, which can be folded up against the sides of the cabin, or removed for a series of all-freight operations. The buffet area is at the rear, where there are also two toilet compartments. The flight deck (pleasantly roomy) is laid out for two-pilot operation, with a jump-seat for a "resident" engineer, and the radio-navigation equipment has been brought fully up to date for operations on a World-wide basis. There is unusually ample under-floor freight space—limited only, so far as the rear compartment is concerned, by the need to keep the c.g. within approved limits.

These Fred Olsen C-46Rs were, in fact, originally among the many of the type stored at Cairo since the War, and were modified and brought up to the Riddle Airlines (Miami) standard in Venice before being flown to Oslo. Apparently the long period of storage had little or no adverse effect on the basic airframe structures, which were found to be quite sound.

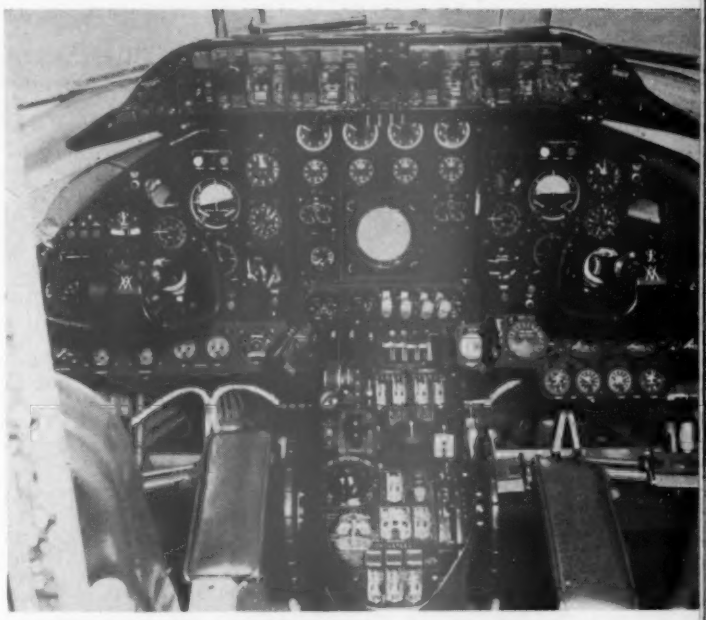
One of the more useful features of the C-46R is the fact that landing and zero-fuel weights (at 48,000 lb. and 47,130 lb. respectively) are conveniently high in relation to the maximum permissible weight. The full-tank endurance (with 1,400 U.S. gallons, or 1,165 Imp. gallons, useable) is about 5 hr. 30 min., plus two-hour reserve fuel; with this tankage the passenger payload (excluding cabin and flight crew) is about 7,700 lb.

More Atlantic Statistics

SINCE we published our review of traffic over the North Atlantic, on a quarterly basis, in our issue of February 7, similar statistics have become available for two further operators. For the sake of completeness, we publish these results below, and they will be consolidated into the total traffic results in graphical form when we publish our next survey, for the fourth quarter of 1957.

In fact, and as one would expect, these additional figures do not alter the trends shown in our February 7 issue in any way, but merely serve to move each curve bodily up the scale. The only slight change noticeable is in the load factor curves; here, the very high average passenger load factors achieved by T.C.A. serve to raise the overall average also in each quarter, contrary to expectation. In the case of the revenue load factor, the results of Icelandic Airlines and T.C.A., when combined with the eight operators already reviewed, serve to flatten out the curve somewhat, by decreasing the three high points and increasing the two low points.

Both the operators covered below recorded satisfactory progress in the period reviewed, the Icelandic increase in total revenue tonne-km. performed being above average. The T.C.A. total tonne-km. figure includes charters.



CONTINENTAL COCKPIT.—The first of the Viscount 812s for Continental Airlines made its initial flight on February 14 from Weybridge. The Continental control cabin layout shown here is interesting because of the central positioning of the display for the R.C.A. A.V.Q.10 weather radar. The instruments on each side of the display are dual-reading torquemeters.

Those Pre-war DC-3s

MAYBE it is not very important—but there has always been some confusion about the number of DC-3s produced by Douglas before the plant was turned over during the War to military C-47 assembly. One quoted figure has been "about 300" and another (derived from a simple subtraction sum) has been the exact number of 803.

In an article in the issue of October 18, 1957, dealing with the early history of some U.S. civil aircraft ("Legendary Misconceptions," pp. 577-578), we quoted the lower figure and were mildly taken to task by that indefatigable researcher, Mr. Dennis M. Powell, a letter from whom was published in the issue of December 13. In a note below that letter, we politely doubted whether the higher (803) number could possibly be right, or whether "about 450-odd were exported to at least 35 non-U.S. airlines between 1936 and 1940."

The mystery of the divergent numbers has now been partially explained. If we accept the totals, given in "Jane's" for 1951-52 from a Douglas source, of 10,123 military DC-3 types built (C-47s, C-53s and C-117s for the U.S.A.A.F. and R4Ds for the U.S.N.) and a grand figure of 10,926 DC-3s built, it is

	3rd qtr. 1956	4th qtr. 1956	1st qtr. 1957	2nd qtr. 1957	3rd qtr. 1957	3rd qtrs. % change	3rd qtr. 1956	4th qtr. 1956	1st qtr. 1957	2nd qtr. 1957	3rd qtr. 1957	3rd qtrs. % change
	ICELANDIC AIRLINES						T.C.A.					
Passengers carried ..	8,842	4,341	3,434	6,896	10,247	+15.9	13,053	9,665	8,906	13,954	15,834	+21.3
Passenger L.F. %	65.5	56.1	51.0	52.1	67.8	—	80.6	79.6	78.5	86.2	78.6	—
Passenger km. (x000) ..	39,115	19,192	15,273	30,935	48,383	+23.8	70,115	52,208	47,368	70,288	84,943	+21.0
Freight tonne-km. ..	135,159	234,133	200,757	199,779	151,084	+11.8	1,196,636	1,316,839	1,269,598	1,194,378	1,074,482	−10.1
Mail tonne-km.	16,917	29,899	20,178	22,151	22,728	+34.5	480,211	677,952	617,434	669,157	645,514	+34.5
Total tonne-km. (x000) ..	3,797	2,034	1,656	3,062	4,681	+23.8	9,004	7,634	7,068	9,352	10,150	+12.8
Revenue L.F. %	60.9	56.4	52.5	54.7	63.6	—	67.2	71.5	73.2	74.0	63.8	—

clear that 803 civil aircraft remain to be accounted for. During 1940, it is known, the 300th DC-3 was delivered to an airline. It is also known (from James Fahey's "U.S. Army Aircraft 1908-1946," pp. 25 and 26) that in 1941 and 1942 the U.S.A.A.F. acquired a total of 194 DC-3-type aeroplanes under the designations C-48/49/50/51/52, prior to deliveries of the C-47.

These aircraft, it is now clear, were those which were on order at Santa Monica for commercial users and which were requisitioned by the U.S.A.A.F. before completion. Before this order was effected—by an Act of Congress towards the end of 1940—the total of DC-3s delivered to users had probably risen to about 330. We are, therefore, still left with about 270 aeroplanes unaccounted for.

They certainly could not have been delivered before Congress forbade the production of additional commercial aircraft. The mystery, therefore, remains. Possible explanations are that the total of DC-3s is wrongly recorded (the military/naval total is confirmed by U.S.A.A.F. and U.S.N. records); that Douglas have counted DC-2s also; that airframes built as spares have been counted; or that Douglas have included in their total ex-military DC-3s which went through the works after the end of the War for refurbishing as civil machines.

Tu-104A Records

IN confirming the various class records set up by a Tupolev Tu-104A last September, the F.A.I. has also given a few more details of the aircraft and the flights. Three record flights were made, on September 6, 11 and 24 last year, and in the course of these flights eleven international records were established in Class C, Group 1, for jet aeroplanes. In each case, the aircraft used was registered SSSR-5421 (we believe this is the first Tu-104A) and the engines were declared as RD-3s with a thrust of 8,700 kg. (19,180 lb.) each. The crew comprised two pilots, navigator, radio operator and flight engineer.

On the first flight, the Tu-104A carried a "charge marchande" (payload) of 20,055 kg. (44,213 lb.) to an altitude of 11,221 m. (36,814 ft.). This qualifies as an altitude record with 20,000 kg., and as a record for the biggest load lifted to 2,000 m. The flight was made from Vnukovo Airport, Moscow.

Next, the Tu-104A completed a flight round a 2,000 km. closed circuit (actually 2,002.6 km.) carrying a payload of 2,000 kg. (4,410 lb.) at an average speed of 897.498 km.p.h. (557.684 m.p.h.). This qualifies as a record distance in a closed circuit, and for speed records over 2,000 km. (1,243 miles) with payloads of 2,000 kg., and 1,000 kg. and without payload.

The final flight was made over a 1,000-km. (621 miles) closed circuit, carrying a payload of 10,000 kg. (22,046 lb.) at an average speed of 970.821 km.p.h. (603.24 m.p.h.). This established five records for speed over 1,000 km., with payloads of 10,000, 5,000, 2,000 and 1,000 kg. and without load.

The two records established by the Mil Mi-6 helicopter on October 30 have also now been confirmed. The helicopter is described as having two 4,700 h.p. TB-2BM turbine engines and was flown from Tushino, Moscow, by two pilots and a flight engineer. A load of 12,004 kg. (26,463 lb.) was carried to an altitude of 2,432 m. (7,979 ft.) and records were established in Class E (for rotorcraft) for altitude with 10,000 kg. load, and best load carried to 2,000 m.

New Independent

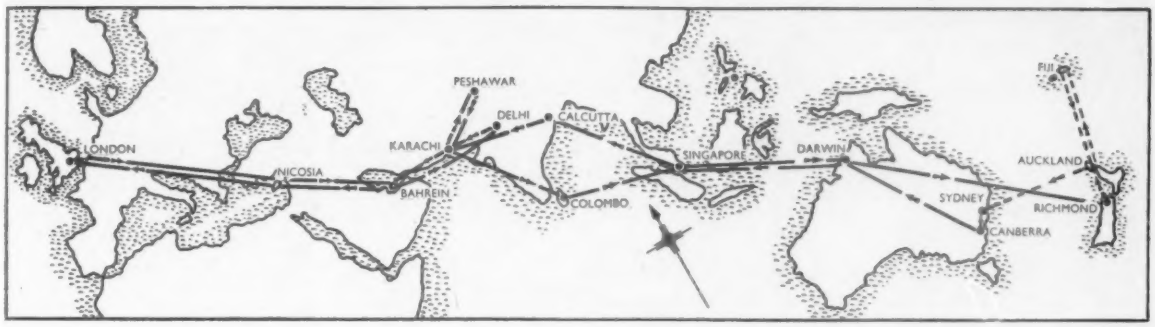
A RECENT newcomer to the ranks of British independent operators is Tradair, Ltd., a company registered last November and now operating from Southend Airport with two Vikings. Shareholders in the company are Mr. E. S. Hanks, commercial director, and Mr. L. N. Monnickendam, technical director; Capt. J. L. T. Allen has more recently joined the board as operational director.

The two Vikings (G-AJFR and G-AJFS) have been purchased from Airwork, Ltd., and are to be used by Tradair with two types of interior, one seating 27 passengers in first-class standard and the other accommodating 36 passengers in high-density tourist seating. Both Vikings are being modified to have a freight-loading door, 8 ft. 3 in. wide and tapering from 5 ft. 9 in. high to 5 ft. 6 in. This modification is being made by B.K.S. Engineering, Ltd., and has been designed so as to avoid a "sill" at floor level, permitting cargo to be slid directly on to the freight floor.

Tradair, Ltd., have contracted a full programme of work in the summer season, for the most part carrying passengers to various European holiday resorts.

Mr. Hanks has considerable commercial experience in aviation, and was one of the founder members of the Airbrokers' Association at the Baltic Exchange. Among other assignments, he assisted in the development of the Airwork Atlantic cargo service. Mr. Monnickendam was an apprentice at Short Bros. and has had wide engineering experience in the industry, and served as an inspector with B.S.A.A. Capt. Allen, who will direct the company's flying operations, has previously served with B.O.A.C., to which he was seconded in 1942.

OFF TO MOSCOW.—Representatives of M.T.C.A. and B.E.A. (left) and the crew of the Viscount 802 seen at London Airport early on February 18 before leaving on their three-day Moscow mission (see THE AEROPLANE, February 14, p.198). The flight crew members (above) are left to right, Capt. H. C. Bailey, Capt. W. Baillie, Capt. G. G. McLannahan, Radio Officer J. A. Dalgleish and Flight Engineer J. Cook.



The Prime Minister's Tour

BRITANNIA G-ANBG arrived back at London Airport on February 14, bringing home the Prime Minister at the end of his six-week-long Commonwealth tour. In the course of this tour, the Britannia flew a distance of approximately 31,000 miles, including a "side throw" to pick up H.M. The Queen Mother in Fiji and fly her to Auckland, and the positioning flights associated with this particular sortie.

Mr. Macmillan was aboard, with his party, on 18 sectors, on which the total flying time was exactly 95 hours. Four arrivals were made on schedule (as was the Queen Mother's arrival in Auckland). Six arrivals were early, with an aggregate saving of 2 hours, and eight arrivals were late, with an aggregate delay of 2 hr. 55 min.

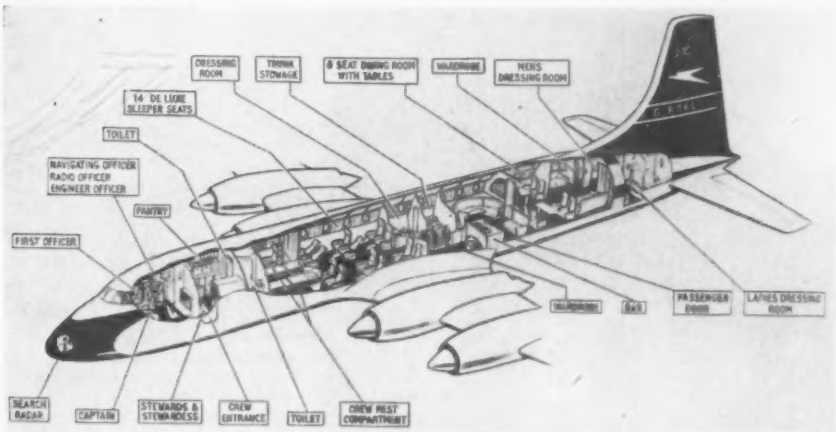
Details of the flight are set out in the table (right) in which all times quoted are G.M.T. The delayed departure from Delhi was occasioned by a change of plan by the official party, and a stop at Agra was then deleted to keep to schedule at Karachi. Only one diversionary landing was made, at Richmond instead of Williamtown. The Prime Minister flew back from New Zealand and Australia by TEAL. Distances shown in the table are Great Circle tracks between the two points.

For this journey, the Britannia was fitted with a V.I.P. interior which can be installed in any Britannia 102 without modifications to the airframe. The layout provides a 14-passenger lounge, with de luxe sleeper-seats, a bar with a semi-circular lounge seat, separate eight-seat dining room and ample wardrobe and dressing-room facilities.

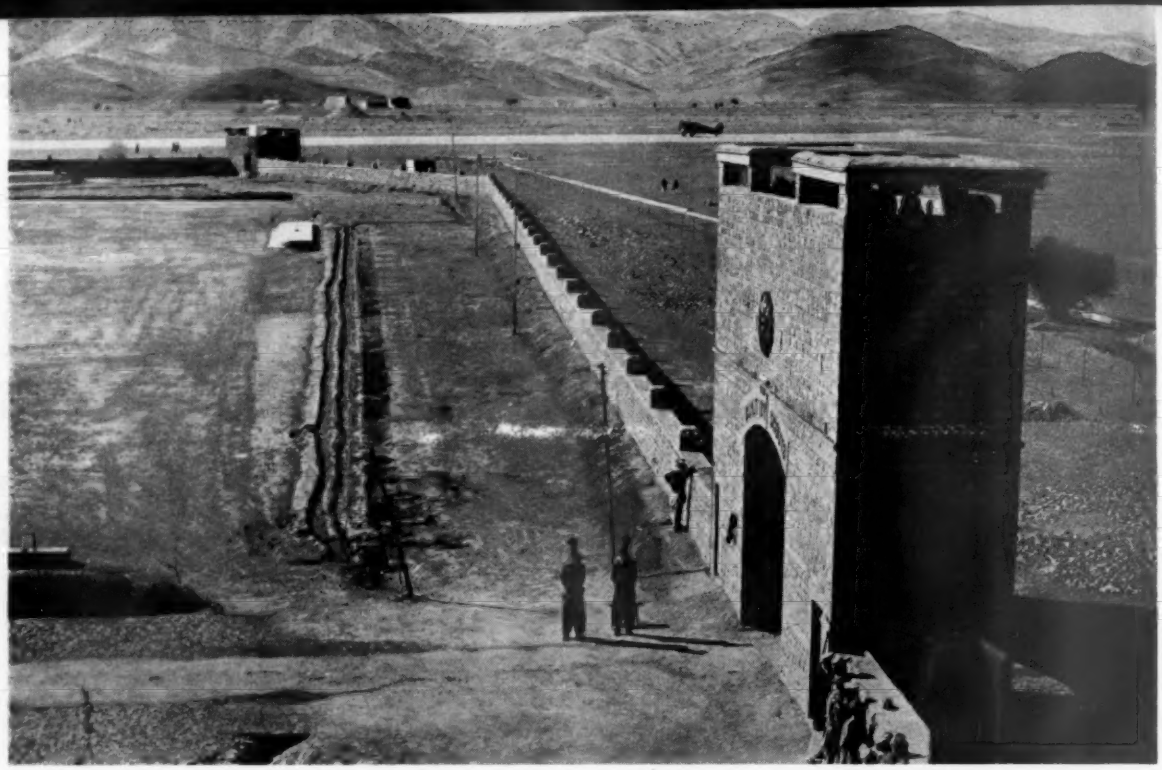
The crews for the tour were provided from the B.O.A.C. "pipeline" down the route, about 80 personnel participating in all. The captains on the various portions of the tour were: London-Bahrein, Capt. E. L. Gosling; Bahrein-Singapore, Capt. A. J. Bullen; Singapore-Richmond, Capt. C. Moore; Richmond-Auckland (and Fiji-Auckland), Capt. R. E. Flower; Sydney-Singapore, Captain E. L. Gosling; Singapore-Calcutta, Capt. M. Lincoln; Calcutta-Bahrein, Capt. B. K. Blackford; and Bahrein-London, Capt. A. J. Bullen.

Date	Terminal		Scheduled time	Actual time	Distance, st. m.
Jan. 7 ..	London ..	*d.*	10.00	10.00	
	Nicosia ..	*a.*	17.30	16.28	2,009
	Nicosia ..	*d.*	18.30	17.45	
	Bahrein ..	*a.*	23.00	23.53	1,197
Jan. 8 ..	Bahrein ..	*d.*	00.01	02.01	
	Delhi	*a.*	07.15	07.01	1,629
Jan. 11/12 ..	Delhi * ..	*d.*	11.15	03.25	
Jan. 12 ..	Karachi ..	*a.*	06.30	06.27	665
Jan. 15 ..	Karachi ..	*d.*	03.00	03.00	
	Peshawar ..	*a.*	05.30	05.36	686
	Peshawar ..	*d.*	10.30	11.30	
	Karachi ..	*a.*	13.00	13.49	686
Jan. 16 ..	Karachi ..	*d.*	03.30	03.19	
	Colombo ..	*a.*	09.00	09.05	1,506
Jan. 18 ..	Colombo ..	*d.*	03.30	03.59	
	Singapore ..	*a.*	09.05	09.31	1,698
Jan. 19 ..	Singapore ..	*d.*	07.00	07.00	
	Darwin ..	*a.*	14.00	14.00	2,079
	Darwin ..	*d.*	16.00	16.00	
	Richmond † ..	*a.*	22.20	22.35	1,928
Jan. 20 ..	Richmond † ..	*d.*	—	00.06	
	Auckland ..	*a.*	04.05	03.59	1,361
Jan. 28 ..	Auckland ‡ ..	*d.*	20.15	20.15	
Jan. 29 ..	Fiji ‡	*a.*	01.00	01.18	1,326
Jan. 31 ..	Fiji	*d.*	22.15	22.05	
Feb. 1 ..	Auckland ..	*a.*	03.00	03.00	1,326
..	Auckland ‡ ..	*d.*	—	05.45	
..	Sydney ‡ ..	*a.*	—	10.25	1,333
Feb. 10 ..	Sydney ‡ ..	*d.*	—	01.50	
..	Canberra ‡ ..	*a.*	—	—	148
Feb. 11 ..	Canberra ..	*d.*	10.00	10.00	
	Darwin ..	*a.*	16.50	16.40	1,952
	Darwin ..	*d.*	18.05	18.00	
Feb. 12 ..	Singapore ..	*a.*	01.20	01.20	2,079
Feb. 13 ..	Singapore ..	*d.*	02.00	01.54	
	Calcutta ..	*a.*	07.45	07.53	1,801
	Calcutta ..	*d.*	08.45	08.45	
	Karachi ..	*a.*	13.55	13.55	1,354
	Karachi ..	*d.*	15.10	15.25	
	Bahrein ..	*a.*	19.35	19.48	1,033
	Bahrein ..	*d.*	20.45	21.05	
Feb. 14 ..	Nicosia ..	*a.*	03.45	03.20	1,197
	Nicosia ..	*d.*	04.45	05.31	
	London ..	*a.*	12.25	12.25	2,009

* Departure delayed by change of plan.
† Diversion. Scheduled arrival time at Williamtown.
‡ Positioning flights.



This sketch shows the cabin of the Britannia 102 as laid out for the Prime Minister's tour.



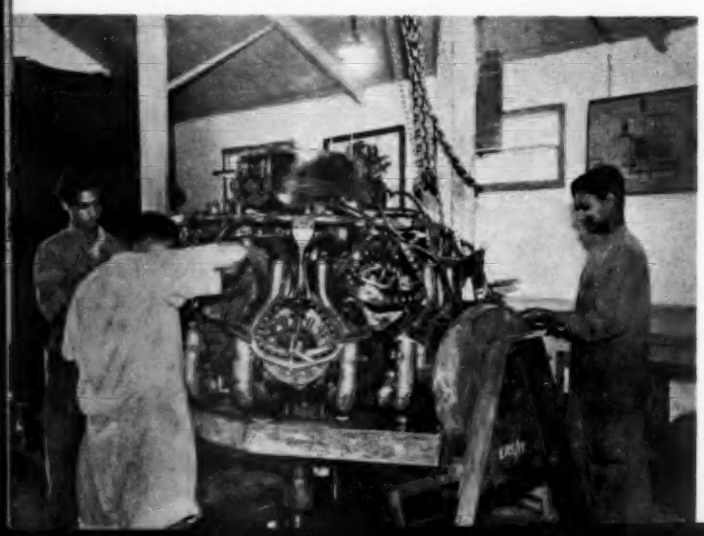
Far-away Frontiers—I

At the invitation of the C.-in-C. of the Pakistan Air Force, JOHN FRICKER *of* THE AEROPLANE *recently toured the Western Province of that country up to the borders of Afghanistan and into Kashmir. These regions have historic associations for the Royal Air Force, and his story of the tour, illustrated by George Moore's photographs, will interest not only all who have served on the North-West Frontier, but all those who want to know more about one of the youngest and most efficient of Commonwealth air forces.*

PAKISTAN, as everyone knows, is in two parts, separated by the 1,100-mile width of India, but at the moment there are no air force units permanently based in East Bengal, so that a tour of the Western Province enables a complete cross-section of the P.A.F. to be seen. Assuming, of course, that you are as fortunate as we, in being privileged guests of the Pakistan Air Force and similarly provided with a V.I.P.-furnished Bristol Wayfarer, an enthusiastic crew and a competent and informative conducting officer. We owe a great debt of gratitude for a truly memorable experience, not only to the C.-in-C., Air Vice-Marshal M. Asghar Khan, but to everyone in the P.A.F. for their hospitality and kindness, and we hope in these articles to convey something of the tremendous impression of efficiency of all ranks which was most apparent throughout our tour.

The P.A.F. is moulded in the fine traditions of the Royal Air Force, and although Pakistan is a completely independent member of the Commonwealth, and the recipient of fairly large-scale American aid, its air Service is anxious and determined to maintain its ties with the R.A.F. This was emphasized to us during our initial interview with the C.-in-C. and we found during our tour that all the fine messes and facilities established by the R.A.F. in the early 'twenties throughout W. Pakistan have been maintained to the same high standards by the P.A.F., whose personnel have carefully preserved many relics of two decades or more of the British sojourn. This is not to say that the P.A.F. does not have a unique spirit of its own; nobody who saw the Mauripur display (THE AEROPLANE, February 14) could dispute that, but it is a compliment to both Services to say that the best features of the R.A.F. have been retained by the Pakistanis, and an entirely comparable level of flying efficiency achieved.

For so young a country this is extremely creditable, but youth itself may be a contributory factor. The Commander-in-Chief is about 37 years old, and most of the other senior officers are in their middle thirties, so that the Pakistan air staff brings a very fresh approach to its tactical problems. At the same time, its members have a high level of experience; all have served for many years with the R.A.F. or former Indian Air Force, and most of them, including the C.-in-C. and the A.O.C. No. 1 (Operational) Group, are fully rated jet pilots in current



Above, symbolizing the title of this series is this view of Miran Shah, a P.A.F. fortified airstrip about 12 miles from the Afghanistan border. Left, assembling a Bristol Centaurus after overhaul at Drigh Road.

Photographs copyright "The Aeroplane"

practice. In addition to various flying courses in the U.K., all officers from the rank of Wing Commander and above have attended Staff College courses with the R.A.F. or joint Services, so that their air outlook conforms generally to the Commonwealth ideas.

English is the language of the P.A.F., and their vernacular is pure R.A.F. A common operating tongue is essential, since W. Pakistanis speak Urdu and those from the East use Bengali, while English becomes mandatory as the international aeronautical medium throughout the free World. All recruits for both air and ground duties in the P.A.F. have therefore to study English, and a relatively high educational standard is required from all applicants, whatever their duties. The overall quality of P.A.F. personnel is therefore very good, despite the inherent lack of mechanical knowledge compared with their more sophisticated Western counterparts. This makes them slower to learn some of the basic facts of mechanical engineering, on which boys in the West are born and bred, but they are correspondingly more methodical and very competent once trained.

These and other problems peculiar to Pakistan we discussed at Air H.Q. Mauripur, just outside Karachi, with the C.-in-C. and other senior officers, including Air Cdre. J. K. Rotherham, O.B.E., B.A., D.I.C., A.F.R.Ae.S., R.A.F., who is one of the three R.A.F personnel still attached to the P.A.F. All three R.A.F. officers are in the Technical Branch, and Air Cdre. Rotherham is the A.C.A.S. (Maintenance). Like all air forces, the P.A.F. has its own spares problem, but, on the whole, its serviceability is remarkably high, and the Sabres have settled down after just over a year of service with very few maintenance snags. Spares difficulties had virtually grounded the P.A.F.'s two communications Doves, but these were to be overhauled by a Pakistani firm and returned to service.

At the time of the display at Mauripur, six squadrons of Sabres were stationed there, according to the C.-in-C., and two more were forming, but these units were to be dispersed as various airfields were extended. These would include Drigh Road, the other Karachi airfield, Quetta, Lahore, Sargodha and Peshawar, all of which would be suitable for jet operations. Many large airfields had been built in the Punjab during the War, but only a few were still maintained by the P.A.F. E. Pakistan was similarly placed for airfields, but its flying conditions were very different, particularly in the five-month rainy season every year, when instrument flying was the rule rather than the exception.

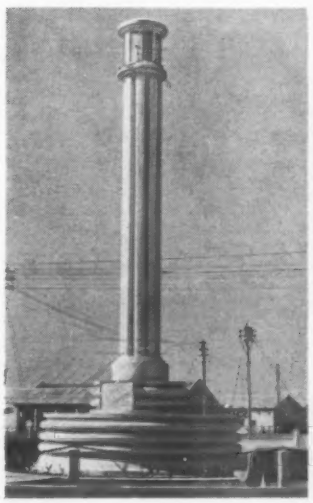
Other points mentioned by Air Vice-Marshal Asghar Khan were the desirability of attaching young P.A.F. pilots to R.A.F. fighter squadrons to gain experience, and the re-equipment problem. Mr. Macmillan had been sounded on the prospect of exchange postings for P.A.F. pilots, but the difficulty was apparently the increasingly limited flying being done by Fighter Command and 2nd T.A.F. So far as re-equipment was concerned, the most urgent need was for a basic jet trainer. Both the Hunting Jet Provost and the Air-Fouga Magister had been evaluated by the P.A.F. and favourably reported on as a Harvard replacement, but the P.A.F. would naturally like to get all its new equipment through the U.S. aid programme. As no suitable U.S. basic jet trainer is available, a European design would be required, through offshore procurement, but this seems unlikely at the moment. A possible alternative was to be given some more Lockheed T-33s, so that flying time on the Harvard could be reduced in favour of more jet flying during pre-Wings training.

The arrival of the Sabres, late in 1956, enabled Pakistan's first jet fighters, the Attackers, to be honourably retired, but these are kept in careful storage for use again if necessary. And it was only at the time of our visit that the P.A.F.'s first operational aircraft—Hawker Tempest 2s—were being finally disposed of, after several years of retirement.

Karachi Activity

Before setting off up country we visited some of the P.A.F. installations in the Karachi area, starting with the School of Aeronautics at Korangi Creek. The P.A.F. equivalent of Halton, this is pleasantly situated on the site of the former B.O.A.C. flying-boat base, a few miles south of Karachi, and was taken over for air force use early in 1950. Like many other P.A.F. institutions, the apprentices training school was originally set up by Air Service Training, Ltd., who laid out the laboratories in "Halton Block," the former terminal building, and equipped the various workshops round the main square. Korangi Creek owes a great deal, as a P.A.F. technical training centre, to the enterprise of Air Marshal Sir Richard Atcherley, who, as one of the initial R.A.F. Commanders of the Royal Pakistan Air Force introduced several long-term measures for ensuring a consistent flow of suitable recruits and trained personnel. His contribution is acknowledged by the "Atcherley Tower," erected just within the gates of the station area.

The P.A.F. took over completely the operation of the School about three years ago, and are continuing the courses for apprentices (three year), mechanics and fitters (one year), officer training, and F-86 familiarization. All the Sabre systems—hydraulics, fuel, air-conditioning, electrics and so on—have been received from the U.S. set up in working layouts for instructional purposes, and pilots and ground crews converting to the F-86 attend a course at Korangi Creek, for complete familiarization. Among the students on Sabre courses at the time of our visit were three pilots from the Royal Jordanian Air Force, who are to fly with the P.A.F. for a few months. The training is also undertaken of a few apprentices and mechanics for Pakistan International Airlines, the national air



Above, this tower at Korangi Creek pays tribute to Air Marshal Atcherley, one of the R.A.F. C.s-in-C. of the P.A.F. Top right, Hawker Fury FB.60s, of No. 9 Sqn., P.A.F., seen (right) with some of their pilots and Tochi Scout officers at Miran Shah.

carrier, and with these students, the total trainee strength was about 648 at the time of our visit.

In a tour of inspection, under the guidance of Wg. Cdr. A. Mannan Khan, the present C.O., we were impressed by the excellent facilities and comprehensive equipment available for instruction. All types of sectioned piston and jet engines were available for demonstration, from old Armstrong Siddeley Cheetans and Rolls-Royce Welland W2B turbojets to the latest Bristol Centaurus and General Electric J47, and representative equipment was on display in each of the sections for airframes, armament, instruments, electrics, etc. The F-86F equipment included the 0.5-in. Browning M-3 machine-gun, the A-4 gun-sight, with APG-30 radar ranging, the J-2 radio compass and the MA-3 underwing rocket pod, containing seven 2.25-in. FFAR. Ten of these pods can be carried by the F-86F.

From Korangi Creek we drove to Drigh Road, east of Karachi, which is the main maintenance station for the P.A.F., and is responsible for its entire fourth-line servicing. Drigh Road (pronounced Drigg locally) was one of the main R.A.F. Depôts in India more than 25 years ago, and is now the headquarters of the new No. 2 (Maintenance) Group, which was formed only in November, 1957. The A.O.C. No. 2 Group is Air Cdr. M. Akhtar. Responsible for Aircraft Engineering in the Group is Wg. Cdre. W. H. Coast, R.A.F., who showed us some of the facilities at Drigh Road.

Commanded by Gp. Capt. A. M. Allah-Dad, the station comprises four main units, each headed by a Wing Commander, and including Nos. 101 and 102 MUs, an Admin. Wing, and a Base Signals Depôt. At the time of our visit, no flying units were stationed at Drigh Road, because of runway extension to 9,000 ft., but a squadron had previously been based there, and would probably return on completion of the runway, depending on the available accommodation. Apart from a few Bristol Freighters, the only aircraft visible were a number of weather-beaten Tempest 2s parked in bays round the airfield, awaiting disposal.

The P.A.F.'s Freighter fleet is being progressively returned to Drigh Road for essential modification of the wing main spars, following fatigue fractures, and the usual airframe overhauls are also undertaken. Complete overhauls are done of all the piston engines operated by the P.A.F., including the Gipsy Major in the Auster Aiglets, the Harvard's Pratt & Whitney 1340, the Hawker Fury's Bristol Centaurus 18, and the Bristol Hercules 672 and 734 of the Freighter Mks. 21 and 31. Four fully equipped engine test beds are available, one for each type, for bench running and calibration, and a fifth has been built for turbojet engines. The M.U. at Drigh Road previously handled the Rolls-Royce Nenes of the now-stored Attackers, but a section of the piston engine shops is being converted and extended for complete overhauls on the Sabre J47 turbojet. This section should be ready within the next two or three months.

Towards the Hindu Kush

After completing our brief tour of the Karachi area we took off from Mauripur in our Wayfarer Mk. 31 captained by Flg. Off. Sohail, for the North-West Frontier region. We followed the wide and winding Indus, through the rocky aridity of the Sind Desert, with its riparian cultivation, over the enormous dam at Sukkur, and up into the fertile plain of the Punjab. Immediately to our left were parallel ranges of jagged and barren mountains, but ahead and to starboard the five rivers which give the Punjab its name relieved the uniform khaki of the desert with the green of elaborately irrigated agriculture. This region, in fact, has often been called the granary of Pakistan.

Miran Shah, in Northern Waziristan, reached just over 3½ hr. from take-off, was our first point of call, and proved to be a landing strip on a 3,000-ft.-high plateau, entirely surrounded by mountains. It is very close—about 12 miles—to the Afghan border and comprises little more than an old Indian Army fort maintained for police action against tribal outlaws, and manned by the picturesque and historic Tochi Scouts. As we taxied in, in our Wayfarer, half a dozen Hawker Furies of the P.A.F. rolled past us for take-off in preparation for a rocket-firing display for our benefit.

Since Partition, the Pathan tribesmen have quietened down considerably from pre-War days, when Miran Shah was used by R.A.F. Harts and Wapitis on regular detachments to maintain law and order on the frontier, but a similar requirement still exists on a reduced scale. The calibre of the tribesmen was graphically illustrated during the rocket-firing demonstration, which was against a pile of oil drums on the edge of the landing strip. We watched the attack from the safety of the top of the fort, several hundred yards away, but the local tribesmen, who wander freely round the strip, were anxious to retrieve unburnt cordite from the rocket tubes, amid somewhat competitive conditions, and so stood rather closer.

Their average distance from the target as the Furies dived steeply in, one by one, to attack, was in fact about 10-15 yd. They had been told that the 60-lb. rockets, which had concrete practise heads, were fitted with live warheads, but this apparently did not deter them. As the rockets hissed down in pairs, raising clouds of dust round the target, the tribesmen scrambled in to salvage the smoking tubes, even as the next Fury dived in on its run. As it released its RPs, they ambled back a few yards from the scarred earth of the target area, matching the lightning streak of the projectiles with their return to salvage operations.

This sort of thing the Pathan apparently regards as great sport, the slightly severe penalties for miscalculation or mechanical shortcomings only adding to its attraction. Now that the British no longer present themselves as targets, the tribesmen are reduced to shooting up each other, although one Ipi, a time-honoured foe of the R.A.F., still manages to lob the odd shell into a fort from time to time, to keep the Pakistan police and troops on their toes, despite his advanced years. It is for this sort of eventuality that the Furies of No. 9 Squadron, P.A.F., are employed, based at Kohat, about 75 miles from Miran Shah.

No. 9 Squadron (Sqn. Ldr. Zulfiqar) which, with No. 6 (Transport) Squadron, the suppliers of our Wayfarer, was one of the original Indian Air Force units taken over at Partition, is the sole remaining Fury squadron in the P.A.F., and its aircraft are very suitable for low-altitude patrols over relatively long periods with a heavy load of stores. Although they will probably be replaced by jets within the next year, this will inevitably involve a change in tactics, particularly as Miran Shah is not suitable for jet operation. The landing-strip could probably be extended, but the main problem would be fuel stocks, since there is no rail connection in the vicinity. This means that frontier patrols will have to be flown from Kohat and Peshawar, further complicating the low-altitude endurance problem.

At the moment, on the rare occasions when detachments are required at Miran Shah, at the request of the political agent, the aircraft are brought within the boundaries of the fort at night, just as they were in R.A.F. times. The individual hangars built for Harts and Audaxes are still in existence, but are too small for the newer Hawker fighters. Despite their rather lonely life, the Pakistan personnel serving at Miran Shah apparently enjoy the solitude, sunshine and good mountain air, and the mess is comfortable enough to offer considerable compensation. Having been built in about 1890, the fort retains a magnificent vintage atmosphere, and the mess is furnished with numerous relics of the turbulent history of the area. These include a collection of mess silver presented from time to time by various army and air force units, and numbering a beautifully made Hawker Hart among its pieces.

We had a first-class buffet lunch amid these historic surroundings, after which the local tribesmen provided some light music in their own manner, and before taking off for Kohat we were treated to a special display of tribal dancing by the colourful Tochi Scouts.

(To be continued)

The picturesque mess in the old Indian Army Fort at Miran Shah contains many interesting relics of the historic past of the North-West Frontier region. It is now occupied by the Tochi Scouts.

Photograph copyright "The Aeroplane"

THE FIGHTING SERVICES

R.A.A.F. Move to Malaya

NOW being formed at R.A.A.F. Amberley, the base squadron of the R.A.A.F. units of the Commonwealth Strategic Reserve is to go to Malaya in the very near future. Advance elements of the unit will fly to R.A.F. Butterworth in March and the remainder will follow in May, so that it will be in full control of the station by the time the first operational squadron moves up from Australia.

A major part of the R.A.A.F.'s No. 2 Airfield Construction Squadron, which has been engaged for several years in rebuilding the R.A.F. base for occupation by Australian squadrons, will also transfer back to Australia in May and the remaining sections, with equipment, will leave Malaya in October of this year.

At present it is planned that No. 2 Squadron operating Canberra B.Mk.20s, from No. 82 (Bomber) Wing at Amberley, will transfer to Butterworth on July 1. This squadron will be followed in a few weeks by No. 114 Mobile Control and Reporting Unit which is now training at Dubbo, N.S.W., so that it can work up to an operational status before No. 78 (Fighter) Wing is posted in.

Nominally a full fighter wing, No. 78 Wing at Butterworth will consist of only two squadrons—Nos. 3 and 77—with No. 75 Squadron remaining at its present base of Williamtown as a reserve squadron. Fully equipped with Commonwealth Avon-Sabres, the two squadrons will be supported by a wing headquarters and a maintenance squadron. The original Avon-Sabre order was for 90 aircraft, and another for 21 Sabres has been placed.

No. 1 Squadron, which has been operating Lincolns from R.A.F. Tengah, Singapore, since July, 1950, will return to Amberley in July, 1958. It will then re-equip with Canberras and replace No. 2 Squadron in No. 82 (Bomber) Wing. When these moves are completed, Butterworth will become a completely R.A.A.F. base under R.A.A.F. command.

To support and reinforce the squadrons in Malaya, the R.A.A.F. transport squadrons are being reorganized. In preparation for the delivery of the 12 Lockheed C-130 Hercules order by Australia, No. 86 (Transport) Wing at Canberra is to be transferred to Richmond, N.S.W., later this year. No. 36 Squadron will be re-equipped with the C-130s, No. 38 Squadron will retain its Dakotas and become a transport training squadron; No. 34 V.I.P. Flight, equipped with Convair 440 Metropolitans and Dakotas, is to remain at Canberra.

Benson Experiment Results

AS a result of the experiment at R.A.F. Benson to raise morale by simplifying and liberalizing administration wherever possible without undermining discipline or efficiency, a number of improvements have been introduced. These cover a wide range of administrative subjects, including airmen's off-duty and personal problems.

The number of parades has been greatly reduced. Regular morning station parades have been abolished, and colours are now hoisted by sections in rotation. Central pay parades have for the most part been replaced by an arrangement under which airmen are paid in their sections. Clothing parades have been almost eliminated; airmen can normally obtain clothing from stores.

Simpler procedures have been introduced for airmen arriving or leaving the station on posting. In most Commands it has proved possible to relieve airmen of the formality of booking in and out. Apart from trainees, airmen over 18 who are allowed to live out no longer need to have a special pass. Simplified arrangements have also been made for airmen reporting sick.

When small parties of airmen travel on duty, subsistence allowances may now be issued instead of haversack rations. Drafting during weekends is avoided as far as possible. Airmen may now wear plain clothes in dining-halls if they are off-duty. Much of the webbing equipment formerly issued to airmen has been withdrawn. Except for recruits and boys, the marking of personal kit is now optional. Families' officers are now appointed at stations where there are married quarters or hirings and help airmen and their wives with the various problems arising from Service life.

Staff College Lecture Tour

AIR VICE-MARSHAL S. C. ELWORTHY, C.B.E., D.S.O., M.V.O., D.F.C., A.F.C., Commandant of the R.A.F. Staff College, Bracknell, and five members of the directing staff are to leave the United Kingdom on March 7 for a two-week visit to the United States and Canada. Travelling by the U.S.A.F. Military Air Transport Service, the team will lecture on the R.A.F. at the Air Command and Staff College of the U.S.A.F. at Maxwell A.F.B., Alabama, and at the R.C.A.F. Staff College, Toronto.

A Staff College team made a similar lecture tour early last year under the system of exchange visits which has been in force between the colleges for some time. In addition to A.V.M. Elworthy, this year's team consists of Gp. Capt. M. D. Lyne, Gp. Capt. L. D. Mavor, Wg. Cdr. B. G. Frow, Wg. Cdr. R. L. Wade and Wg. Cdr. C. B. Brown.

R.A.F. Appointments

THE following are among recent Royal Air Force appointments:—

Wing Commanders: E. J. Brooks, D.F.C., to R.A.F. Rufforth to command; H. D. Campbell, to Headquarters, Coastal Command, for administrative staff duties; R. E. W. Harland, to M.o.S., for duty in the U.S.A.; C. R. C. Howlett, to Headquarters, Fighter Command, for technical staff duties; L. J. Joel, D.F.C., to M.o.S., Boscombe Down; P. A. Kennedy, D.S.O., D.F.C., A.F.C., to R.A.F. Wildenrath, to command No. 31 Squadron; A. McArthy, to R.A.F. Linton-on-Ouse, for technical duties; A. D. Rutherford-Jones, to No. 114 Maintenance Unit, Aden, to command.

Acting Wing Commander A. Mackelden, to R.A.F. Jever, for technical duties.

Squadron Leaders: E. Batchelar, to Headquarters, No. 11 Group, for air staff duties (with the acting rank of Wg. Cdr.); D. N. Shepherd, D.F.C., to R.A.F. South Cerney, to command No. 1 Wing (with the acting rank of Wg. Cdr.).

FIGHTER ACTIVITIES.—Commonwealth Avon-Sabres of No. 78 (Fighter) Wing, and Meteor F.8s and a Vampire at R.A.A.F. Williamtown. As recorded on this page, Nos. 3 and 77 Squadrons of the Wing, together with No. 2 (Bomber) Squadron, are to be transferred to Butterworth, Malaya, later this year.

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Lord Trenchard Honoured at Halton

THE evening of February 20 saw a distinguished occasion at Halton, where the Chief of the Air Staff, Marshal of the R.A.F. Sir Dermot Boyle, delivered the first Trenchard Memorial Lecture before the Halton Branch of the Royal Aeronautical Society. His lecture, "Lord Trenchard," was heard by a large and distinguished Service and civilian audience which included Lady Trenchard and the present Lord Trenchard.

The guests were welcomed by Air Vice-Marshal H. D. Spreckley, A.O.C. of No. 24 Group and vice-president of the Halton Branch of the R.Ae.S. Air Vice-Marshal G. Silyn Roberts, president of the Halton Branch, then spoke.

The lecture was introduced by the president of the R.Ae.S., Sir George Edwards. He said he felt that if Lord Trenchard himself could have chosen the lecturer he would have chosen no other than the first C.A.S. who had come from Cranwell, Sir Dermot Boyle.

Following the lecture Sir George said that it was customary for there to be no discussion, but he asked the Commissioner of the Metropolitan Police, Sir John Nott-Bower, to speak about Lord Trenchard's work for the police.

A vote of thanks to the lecturer was moved by Maj. G. P. Bulman, R.Ae.S. treasurer, who spoke of Lord Trenchard's essential humanity, modesty and simplicity. He mentioned an incident which occurred in 1917. A squadron had been equipped with a new type of aircraft; many of these had crashed and the squadron's morale was very low. Trenchard had heard of this and arranged for himself to be flown to the squadron in one of these suspect aircraft. He lunched with the squadron, spoke of many things without mentioning the aircraft which worried them, and had been flown away, again in one of the aircraft they regarded as death-traps.—J.R.C.

Naval Aviation in the Future

A LARGE proportion of the more outstanding changes planned for the Royal Navy during the next three years is centred on naval flying and guided-missile developments. Last week's Naval Estimates for 1958-59 include details of the concentration of Home Air Command into larger groups at fewer bases, the commissioning of a commando carrier, the introduction of the D.H. Sea Vixen and Supermarine Scimitar into squadron service, and the naming of the carriers which will be capable of operating the Blackburn NA.39.

Introducing an explanatory statement on the Estimates, the First Lord of the Admiralty, the Rt. Hon. The Earl of Selkirk, stated that the Service was embarking on a period of very rapid change; the new weapons being introduced were not replacing the old but rather extending the overall range. Carriers will continue to be the core of the Navy although the main rôle of the Fleet was being changed to that of hunting down and killing enemy submarines. The latest weapon for this is the anti-submarine helicopter with Asdic and a homing torpedo.

It is intended to have two aircraft carriers at sea in the NATO areas with a third in immediate reserve. In addition, one carrier with supporting ships is to be continuously maintained east of Suez; this fleet will have the fighter and strike aircraft necessary to protect itself and to support ground operations. It will also be able to deal with any submarine threat in the event of a limited war in the area and will be reinforced by the proposed commando carrier.

The carriers at present in service are "Eagle," "Ark Royal" and "Bulwark," with the last two being replaced by the "Victorious" and "Centaur" later this year. To follow the general policy already described, the "Bulwark" will be deployed east of Suez during 1958 until relieved by the "Albion," at present refitting, at which time the "Bulwark" will return to the United Kingdom for conversion to the rôle of commando carrier.

Altogether there are nine aircraft carriers on the present strength of the Royal Navy. During the coming year four —"Eagle," "Victorious," "Centaur" and "Albion"—will be in the operational fleet or preparing for service with it, and the other five—"Ark Royal," "Bulwark," "Triumph," "Magnificent" and "Warrior"—will be undergoing extended refit, modernization or conversion with the Reserve.

Planned to replace the Sea Hawk, the first operational squadron of Scimitars will be formed in June and will embark in the "Victorious" in September. These will be followed by the Sea Vixen, armed with Firestreak air-to-air missiles and rocket batteries, which will give a greatly increased destructive power to the Fleet Air Arm. The last of the trio of the present new Naval aircraft—the NA.39—is expected to fly this year, and three carriers, "Victorious" and "Eagle" (preparing for service), and the "Hermes" (now under construction), will be ready to operate this new strike aircraft.

As already mentioned, the tasks of the Home Air Command will be concentrated in larger groups at fewer bases, and six air establishments will be closed over the next three years, in addition to R.N.A.S. Anthorn and Stretton, which are already closing. The six establishments are R.N.A.S. Ford and Bramcote, to be closed early in 1959; R.N.A.S. Eglinton, to close in the first half of 1959, and R.N.A.S. Brawdy, to be closed in 1960, but kept in reserve; the Air Electrical Training Establishment, Worthy Down, to close in 1960, and its task transferred to R.N.A.S. Lee-on-Solent; and the Aircraft Repair Yard at Donibristle, which is unsuitable for the latest types of aircraft, will be closed by the end of 1959.

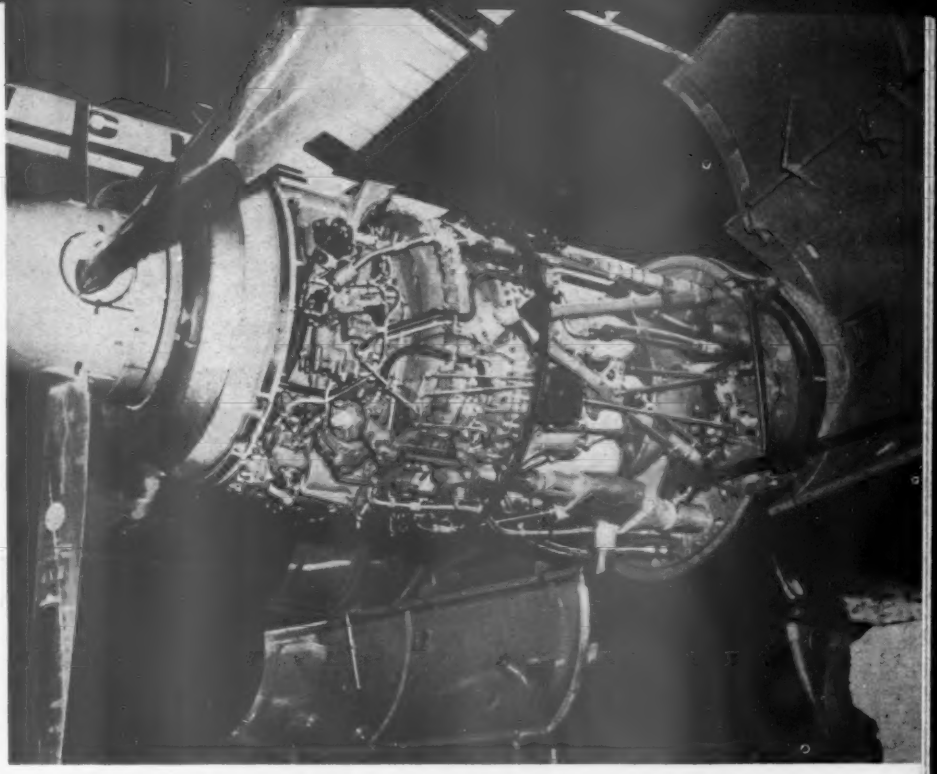
This means that the air stations remaining in service after 1961 will consist of Yeovilton, Lossiemouth, Culdrose, Abbotsinch, Arbroath, Lee-on-Solent, Belfast and Fleetlands. In addition, a small part of the Home Air Command task will be accommodated at R.N.A.S. Hal Far, Malta.

Guided missiles are well to the fore for the future armament of R.N. ships as well as aircraft. The trial firings of the Armstrong Whitworth Seaslug ship-to-air weapon in the guided-missile trials ship "Girdle Ness" have achieved a marked degree of success; the weapon may also be capable of development as a ship-to-ship weapon. Four guided-missile destroyers for operating the Seaslug have been ordered.

The first anti-submarine helicopter squadron, equipped with Westland Whirlwind H.A.S.7s, came into service in the second half of last year and others are being formed. Described in THE AEROPLANE of February 7, 1958, the H.A.S.7 is to be replaced by the Wessex, which is under development. The Fairey Gannet is going out of service.

Fleet Air Arm requirements for pilots and observers continue to be met from general-list officers, and from officers entered direct from civil life or promoted from the lower deck to supplementary-list commissions.

Darts for Today and Tomorrow



ACCENT ON ACCESS.—Ease of access for servicing could not be better than for the Dart R.Da.7 engine installation in the Vickers Viscount. Engine mounting well forward of the wing gives all-round accessibility.

MUCH WATER has flowed under the Clapper Bridge at Dartmeet, in Devonshire, since the Rolls-Royce Dart turboprop engine design was started in 1945, and many tons of air have been swallowed during four million hours of revenue-earning operation in scheduled airline service by this remarkable engine.

The most outstanding aspect of the Dart is not its simplicity, its performance, its reliability nor its long life between overhauls—it is that the basic layout and dimensions have hardly changed in a period of over 12 years when many radical steps have been made in the evolution of the gas-turbine aero-engine. The reasons are simply that the layout was correct and that it has been better consistently to develop the engine than to "cut and come again" with a completely new design every so often.

This, of course, is the proven method of successful mechanical engineering, which has been exemplified in many fields, whether it be the Vickers Viscount, the original *traction avant* Citroën car, the Douglas DC-3 or the Rolls-Royce Dart. Each was so far ahead of its time that years of development lay ahead and only a completely new requirement for a different order of performance resulted in respective advances now existing as the Vickers Vanguard, the DS19 car, the Douglas DC-8 and the Rolls-Royce Tyne.

In setting out to design their first turboprop engine, the experimental Trent (the first turboprop in the World to fly, in September, 1945), Rolls-Royce could draw on unrivalled experience as aero-engine manufacturers in both the piston and turbojet fields. Knowledge of the characteristics of centrifugal compressors used for the Merlin and Griffon reciprocating engines had been gainfully employed on the Welland and Derwent turbojets with great success, and it was decided to use this type of compressor for the Dart in two-stage form with a two-stage axial-flow turbine driving it and seven separate combustion chambers.

FOR THE FUTURE.—Four Rolls-Royce Dart R.Da.7 Mk. 526 turboprops of 2,105 e.h.p. will be used in the Armstrong Whitworth A.W.650.

The first Dart to enter regular scheduled service—in B.E.A Viscounts—was the R.Da.3 Mk. 505, of 1,400 s.h.p. The Mk. 506 had higher power in cruising flight because of aerodynamic improvements to the compressor design which involved the use of polished, thinner-section rotating guide-vanes. Take-off shaft horse-power remained at 1,400 because of the reduction-gear capacity. All Dart Mk. 505s have since been modified to Mk. 506 standard. The biggest operator of the Dart. Mk. 506 is Trans-Canada Air Lines.

The next major step in development, as distinct from the constant process of detail refinement which goes on with any aero-engine, was the R.Da.6 Mk. 510, of 1,600 s.h.p. This more powerful engine had a bigger reduction-gear load capacity, a different gear ratio and turbine-blade tip-seals.

Whereas the first Dart reduction gears had straight-cut, low-speed trains and helical high-speed trains, the Mk. 510 had both trains of helical form, and this has been retained—with wider gear teeth to transmit the further increase in power—in the latest Dart R.Da.7 Mk. 520 series, the first production Darts to have a three-stage turbine.

Design Details of the R.Da.7

The R.Da.7 has an air mass flow about 10% greater than the R.Da.6. Rotating guide-vanes and impeller of the first stage of the centrifugal compressor are not modified, but the throat area of the diffuser is enlarged. This has the effect of reducing the pressure rise of the first stage slightly, but this is more than recovered by the 0.4-in. larger diameter of the second-stage impeller. Engine speed at take-off power is increased from 14,500 to 15,000 r.p.m. Modifications to design of the combustion chambers include the addition of a third cooling-ring strip and an increased outlet diameter.

There is less pressure-loss in the R.Da.7 combustion system, due to the punching of more holes in the tertiary area of the flame tubes and to enlarging the flame-tube outlet diameter. Although lives of flame tubes with two cooling rings have already exceeded 3,000 hr., it was thought wise to incorporate a third ring to allow for the increases in performance resulting

from the lower pressure-loss and higher operating temperatures. The nozzle guide-vane areas have been altered to suit the higher mass-flow and the use of a three-stage turbine.

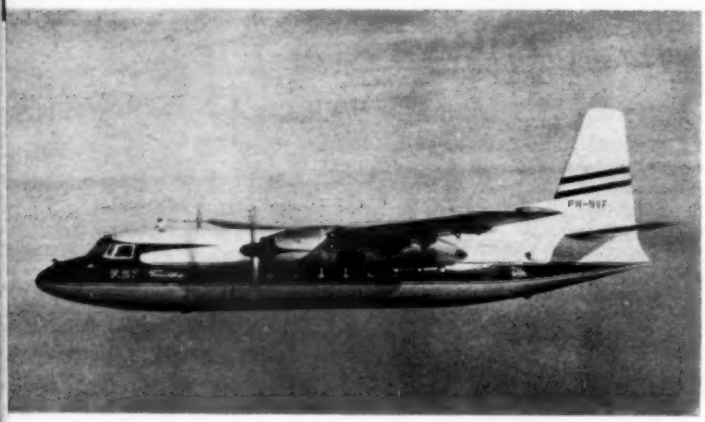
The two-stage turbine of the R.Da.6 was at the maximum loading consistent with high efficiency and a further increase in power dictated the addition of a third stage in order to absorb the extra load of some 310 s.h.p. In going to a three-stage turbine there is less load per stage, and some margin is available for future development (R.Da.10). The three-stage unit is, of course, more efficient in extracting the maximum amount of power to drive the compressor and propeller.

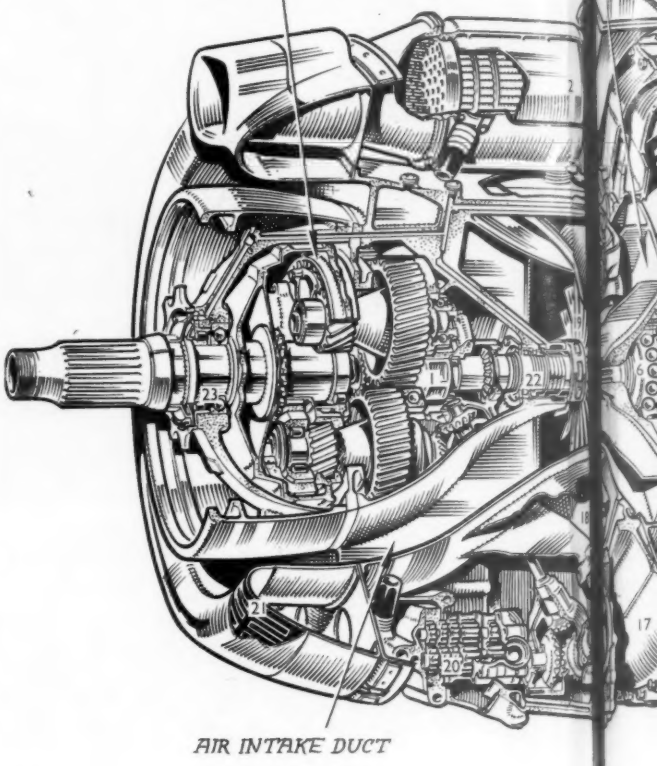
Flame temperature is 15° C. higher than that of the R.Da.6 and this has required the adoption of higher temperature-capacity material for turbine blading. Compared with the earlier engine, which had Nimonic 80A blades for both stages (although Nimonic 90 has been introduced in the Mk. 510), the R.Da.7 has Nimonic 95 high-pressure blades, Nimonic 90 at the intermediate stage and Nimonic 80A low-pressure blades.

The extra power produced by these various modifications has to be transmitted, and a slightly larger-capacity reduction gear is used. As we have noted earlier, this was attained simply by slightly widening the teeth of the helical gearwheels—the rotational centres being unaltered. Propeller reduction-gear ratio is 0.093 : 1, as for the R.Da.6 as used in the Viscount, whereas the R.Da.3 had a ratio of 0.106 : 1. The engine compression ratio is 5.75 : 1.

Alterations in mechanical design are due to the normal

DUTCH DRIVE.—Below, the Fokker F-27 Friendship, in production in Holland and America, has two Rolls-Royce Darts. At present flying with the 1,720 e.h.p. R.Da.6 Mk. 511, the 1,960 e.h.p. R.Da.7 Mk. 528 is an alternative powerplant.



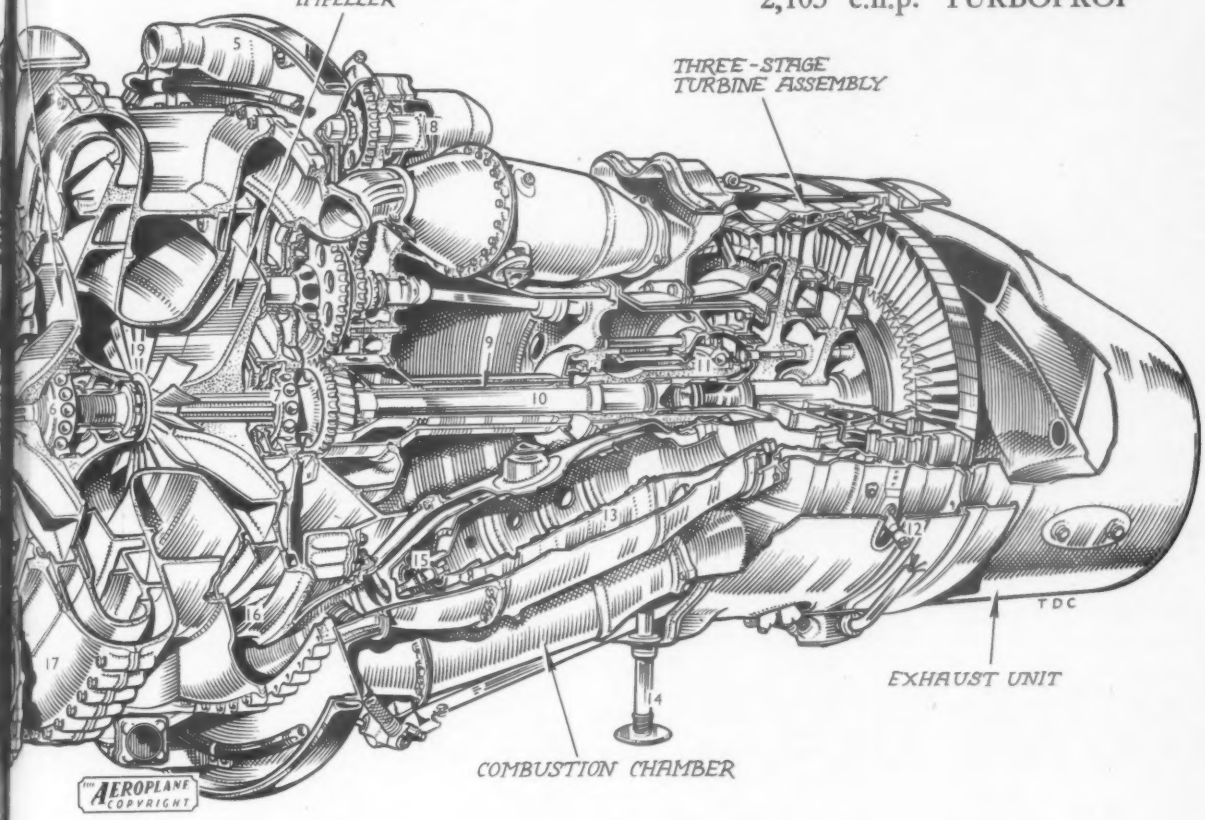


KEY

1. High-speed pinion bearing.
2. Oil cooler.
3. Oil filler filter.
4. Water-methanol feed to impeller eye.
5. Mounting trunnion.
6. Inter[illegible] compres
7. Centi[illegible]ring.
8. Acces[illegible] gearbox
9. Turbi[illegible]mpressor
10. Turbi[illegible]duction-g
11. Rear [illegible]ng.

NACELLED NEATNESS.—Left, as [illegible] passengers will see them, the Dart R.D[illegible] sleekly cowled power-sources project[illegible] ahead of the wing leading edges. Bel[illegible] military application of the Dart R.Da. [illegible] Mk. 21 engine used in the Breguet 10[illegible] French anti-submarine aeroplane.

ROLLS-ROYCE DART R.Da.7
2,105 e.h.p. TURBOPROP



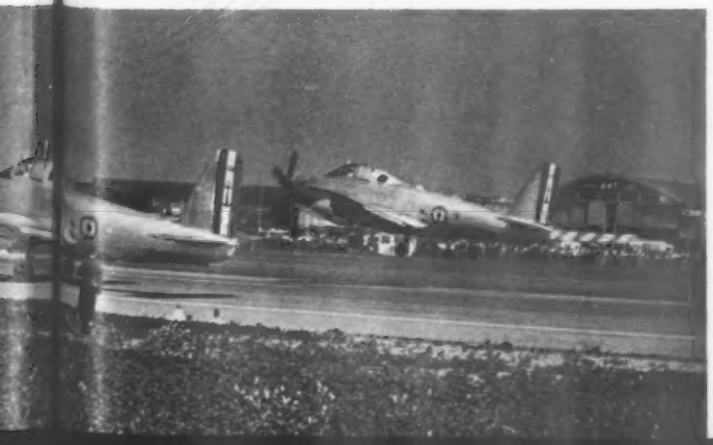
6. Inter[mediate] compressor bearing.
7. Cent[rifugal] ring.
8. Acce[ssory] gearbox drive.
9. Turb[ine] compressor shaft.
10. Turb[ine] reduction-gear shaft.
11. Rear [bearing].
12. Thermocouples in intermediate-stage guide vanes.
13. Flame tube.
14. Cooling air outlet.
15. Fuel burner.
16. H.P. diffuser.
17. L.P. diffuser casing.
18. Oil tank.
19. Rotating guide-vanes.
20. Oil pumps (scavenge and pressure).
21. Dunlop de-icing mat.
22. Compressor shaft front bearing.
23. Prop. shaft roller and ball bearings.

process of design refinement and development and to the changes made necessary by the increase in power. The three-stage turbine is bolted together in an entirely different manner from that of the earlier two-stage assembly, which had a single large annular nut and bolt coaxial with the drive shaft. The first and second stages of the R.Da.7 turbine are fixed together by five bolts; a further five bolts connect first and third stages, passing through the intermediate turbine disc.

A major change in design is the adoption of double transmission shafting. Previous Darts had the turbine, compressor and propeller reduction gear connected "in series," but the R.Da.7 has an inner drive-shaft direct from turbine to reduction gear and an outer shaft connected to the compressor. The object of this is that, in the extremely unlikely event of shaft failure, safe rotational speed limits would not be exceeded.

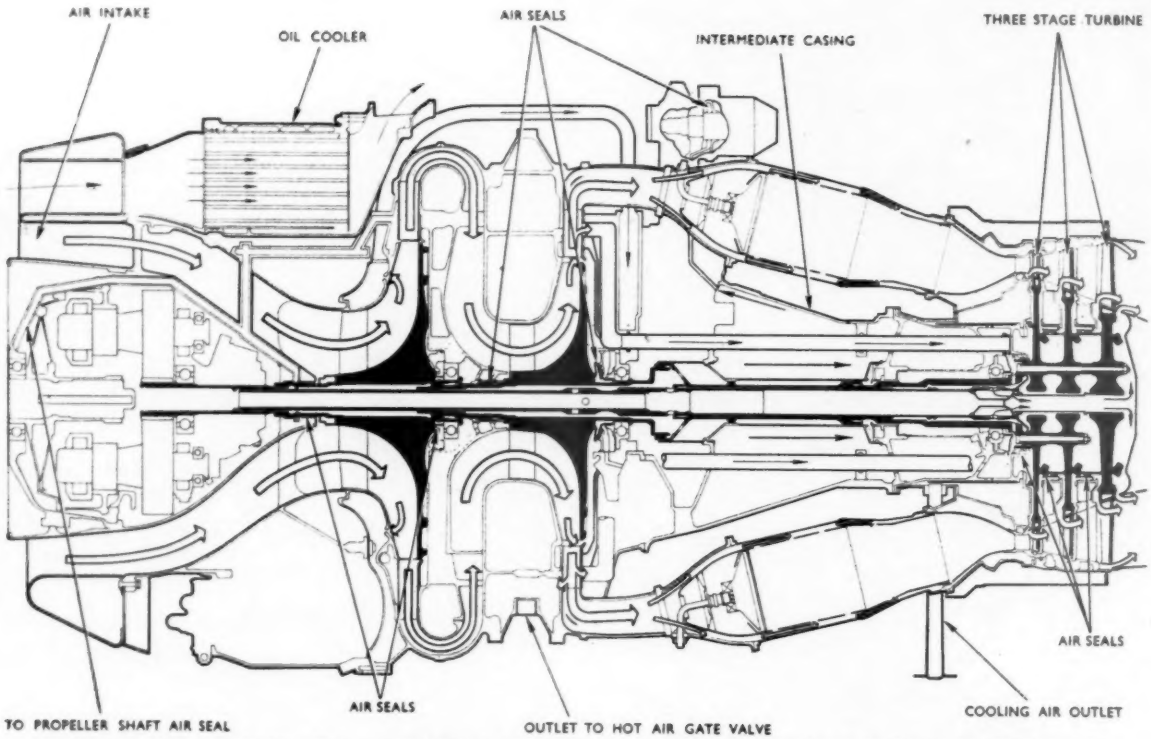
All Rolls-Royce engines have the turbines "contained" by a steel nozzle-box, so that failure of a turbine blade is of no immediate consequence. This does not imply that such failures are anticipated, but represents sound engineering practice coupled with modern design philosophy. A final mechanical change is the incorporation of double-sided steel diffusers downstream of each centrifugal impeller.

A minor difference between the Mk. 520 series Darts and earlier engines is that the thermo-couples are now positioned inside the intermediate nozzle guide-vanes of the turbine instead of in the exhaust unit. This location gives a more accurate indication of the cycle temperature.



Component Life and Materials

In the course of four million hours of airline service the Dart has achieved an almost unapproachable reputation for reliability. Statistics given by Capital Airlines for their Viscounts show that only 19% of mechanical trouble causing delays was attributable to the powerplants, compared with 57% for a piston-engined type. Engine failures were at an average



SEALING AND COOLING.—This cross-section of the Rolls-Royce Dart R.Da.7 engine shows the flow-paths of sealing and cooling air. Also clearly indicated are the transmission double-shafting and the three-stage turbine.

rate of one in 80,000 hr., whereas the comparable rate for reciprocating engines was about 10 times as great.

Trans-Canada Air Lines operate their Dart Mk. 506 engines on an overhaul period of 1,800 hr. and have recently removed two engines for examination after 2,000 hr. The Mk. 5 engines of Capital Airlines have a 1,600-hr. schedule and B.E.A. take 1,500 hr. as their overhaul life. The Mk. 506 Dart in B.E.A. Viscount 700s achieved a 1,050-hr. life within 18 months of its first entering service, a very creditable achievement for a new engine/airframe combination involving a completely new type of powerplant.

Individual components invariably have lives well in excess of the overhaul life period. Flame tubes have reached 3,000 hr. without repair, impellers 3,000 hr., turbine discs 4,000 hr. and some engine "carcases" (including shafts, pilot quantities of high-pressure turbine blades and nozzle guide-vanes) have attained 5,000 hr. in service.

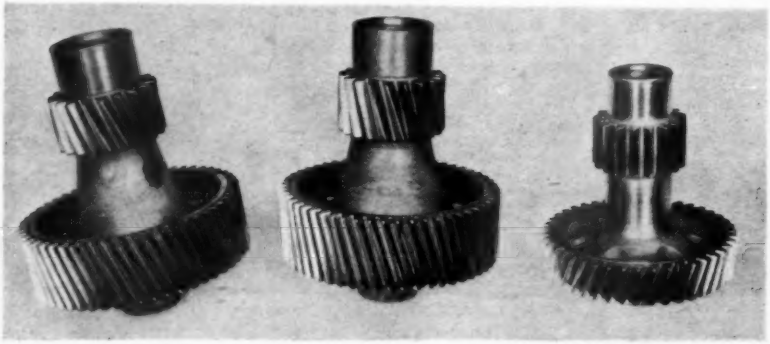
Such excellent results are a result of choosing the right material for the job in each part of the engine and the materials used for the main components are worth noting. Starting at the front of the engine, the air intake casings are of cast magnesium alloy. This material is used back to the first impeller. The main compressor casing and outlet casting are in aluminium alloy, there being the steel diffusers, mentioned above, and a magnesium internal guide casting. Expansion chambers at the heads of the combustion chambers are of aluminium alloy; the combustion-chamber casings are mild steel, and Nimonic 75 is used for the flame tubes.

The truncated cone turbine-support casting, mounted on the back of the compressor, is a magnesium casting. The nozzle-box is of centrifugally cast steel and welded sheet metal. Rolls-Royce C.242 nickel-based casting alloy is the material of the nozzle guide-vanes. Forged nickel-steel is used for the impeller rotating guide-vanes, the impellers themselves being forged aluminium alloy. Reduction-gear casings are in magnesium alloy; engine mounting trunnions and firewalls are of stainless steel.

Present and Future

First application of the Dart R.Da.7 is the Mk. 520 for the Vickers Viscount 806s of B.E.A. This engine develops 1,700 s.h.p. (1,890 e.h.p.) at sea level, at temperatures up to I.S.A.+12° C. without water-methanol injection. It is a de-rated version of the R.Da.7. The slightly de-rated 1,800-s.h.p. (1,990-e.h.p.) Mk. 525 is destined for the Viscount 810, which has a heavier structure to take the extra thrust loads on the airframe and has more potent rudder balancing to counteract take-off swing.

The Viscount engines have a propeller diameter-restriction of 10 ft. because of ground/tip clearance. The high-wing



PROGRESSIVE POWER.—These gear-wheels from Dart reduction gears show the larger capacity dictated by increased engine power. On the right is the original design with one helical and one straight-cut gear used on the Dart R.Da.3 Mk. 506. On the left is the double-helical gear of the Dart R.Da.6 Mk. 510 and in the centre are the slightly wider gears of the Dart R.Da.7 Mk. 525.

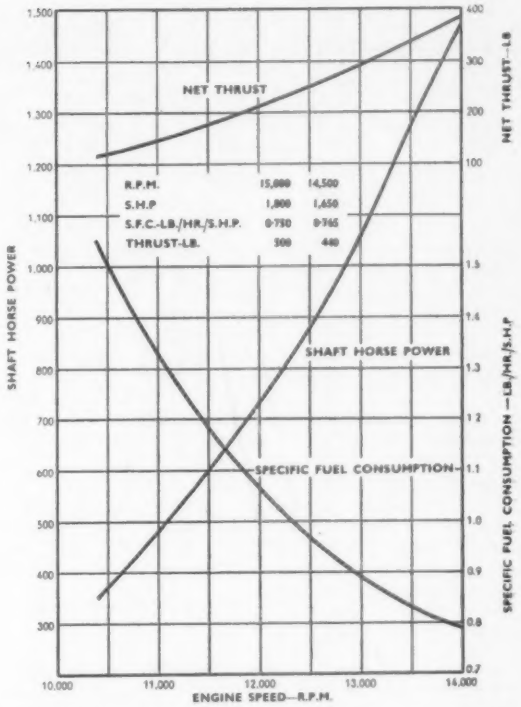
Armstrong Whitworth AW.650 will have 11-ft. 6-in.-diameter propellers with the Dart Mk. 526; the Handley Page Dart Herald's Mk. 527 engines are to have the largest-diameter propellers yet used on a Dart—12 ft. 6 in.; and the Mk. 529 engines for the American Grumman Gulfstream executive transport are to be fitted with 11-ft. 6-in.-diameter propellers. The sole military application of the R.Da.7 is in the Breguet 1050 Alizé.

The Mk. 526, 527 and 529 engines are all of 1,910 s.h.p. and 2,105 e.h.p., the full rating of the R.Da.7 without airframe limitations. A further variant is the Dart Mk. 528 for the later production models of the Fokker/Fairchild F-27 Friendship. An 11-ft. 6-in.-diameter propeller is specified and the 1,960-e.h.p. engine will not normally be used with water-methanol injection to the eye of the first-stage impeller, although provision for this will be made. This power is maintained at sea level up to temperatures of I.S.A.+6° C. With water-methanol in operation the same power will be available up to I.S.A.+30° C.

Next stage in Dart development is the R.Da.10, on which much rig-testing is already complete; the first engine is due to run soon. The R.Da.10 will be of 2,660 e.h.p. and 2,400 s.h.p. For the Viscount 840, a de-rated version of 2,100 s.h.p. (2,350 e.h.p.)—the R.Da.11 Mk. 541—will be used. This will be the Viscount with 400-m.p.h. cruising speed. Viscount 810s may be converted to 840-standard by re-engining with the R.Da.11, which maintains its power up to I.S.A.+14° C. temperature.

The additional performance of the R.Da.10 and R.Da.11 series is obtained by providing 16% greater mass-flow than for the R.Da.7. Thus, the mass-flow will be 25.5 lb./sec. compared with 22.0 lb./sec. for the R.Da.7 and 20.0 lb./sec. for the R.Da.3.

This increased swallowing capacity is provided by enlarging the "eye" of the first-stage impeller, the inlet velocity remaining the same as that of the R.Da.7. Compression ratio of the compressor is increased from 5.75 : 1 to 6.35 : 1 and the diameter of the first-stage impeller has been enlarged to 21 in.

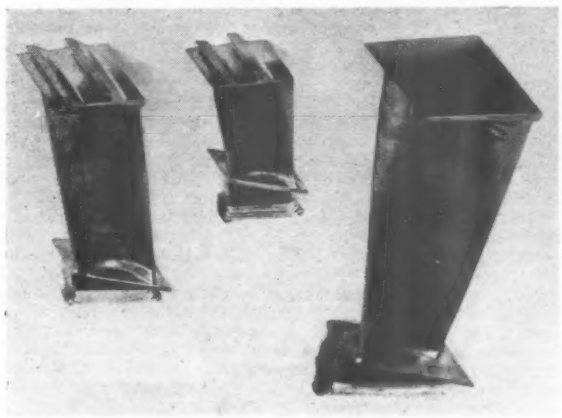


TURBOPROP PERFORMANCE.—Static sea-level performance data for the Rolls-Royce Dart Mk. 525 in I.S.A. conditions.

The air intake annulus is widened and the intake cowl altered in shape so that the same overall nacelle diameter is used as for earlier Darts. A conical spinner profile has been adopted, as with the Tyne turboprop engine. The distance between centres of the reduction gearwheels is increased because bigger gears are necessitated.

Air-cooled turbine blades are used in the high-pressure first stage and a new blading design has been adopted to match the higher mass-flow. Flame temperature at the turbine inlet is increased to 1,225° K. for the R.Da.10 (1,145° K. for the R.Da.11).

From the foregoing it can be seen that a tremendous amount of development work has been put in on the Dart since our first full description in THE AEROPLANE of September 9, 1949. The original design has been improved steadily and such changes as have been made are simply to absorb the extra power developed and to keep the detail design of the various components at least in line with, if not ahead of, current aero-engine practice.—D.G.



TURBINE TIPS.—In centre, left and right positions respectively, are blades from the high-pressure, intermediate and low-pressure stages of the Dart R.Da.7 turbine. All stages have shrouded blade tips, the high-pressure and intermediate stages also having double seals.

ROLLS-ROYCE DART
Static Take-off Performance at Sea-level

Engine	Application	S.H.P.	Lb. thrust	E.H.P.	S.F.C.	R.P.M.	Remarks
R.Da.3 Mk. 506	Vickers Viscount 700 Series	1,400	365	1,540	0.727	14,500	Earliest standard now in service, 10-ft. dia. prop.
R.Da.6 Mk. 510	Vickers Viscount 700D and 800 Series	1,600	370	1,740	0.69	14,500	Double-helical reduction gear introduced.
R.Da.6 Mk. 511	Fokker F-27 Friendship	1,600	310	1,720	0.698	14,500	As Mk. 510, with 11-ft. 6-in. dia. prop.
R.Da.7 Mk. 520	Vickers Viscount 806	1,700	495	1,890	0.70	15,000	Three-stage turbine, double shafting and new red. gear.
R.Da.7/1 Mk. 525	Vickers Viscount 810 Series	1,800	500	1,990	0.68	15,000	Slightly de-rated R.Da.7.
R.Da.7/2 Mk. 526	Armstrong Whitworth A.W.650	1,910	505	2,105	0.66	15,000	Fully-rated R.Da.7, with 11-ft. 6-in., 12-ft. 6-in. and 11-ft. 6-in. dia. propellers respectively.
R.Da.7/2 Mk. 527	Handley Page Dart Herald						
R.Da.7/2 Mk. 529	Grumman Gulfstream						
R.Da.7/1 Mk. 528	Fokker F-27 Friendship	1,800	500	1,960	0.69	15,000	Alternative F-27 power-plant.
R.Da.10	Republic Rainbow† ..	2,400	675*	2,660	0.64	15,000	Most powerful of Dart series.
R.Da.11 Mk. 541	Vickers Viscount 840 Series	2,100	655	2,350	0.675	15,000	Engine for 400-m.p.h. Viscount.

† Project. * Approx.

The Economic Value of Weight Saving

In this study, prepared for Guest, Keen & Nettlefolds (Midlands), Ltd., J. C. Dykes, M.A., M.S., A.F.R.Ae.S., examines in detail the effect of structural weight saving in transport aircraft — with particular reference to the application of titanium bolts and nuts.

IT is axiomatic that every reduction in the empty weight of an aircraft is of value. The direct substitution of steel bolts and screws by titanium, thereby saving nearly half their weight, must therefore attract both manufacturers and operators. Queries regarding their fatigue strength and so on have largely been satisfied in the technical literature, but the questions remain: "Can their higher cost be justified? And, if so, when?"

To assess the economic value of weight savings many engineers use rules-of-thumb such as those devised by the S.B.A.C. (Ref. 1), B.O.A.C., B.E.A. and other airlines. While these are generally satisfactory over a limited range of conditions, they are relatively crude and do not sufficiently indicate the effect of major variables. Without seeking to be definitive, this study demonstrates economic gains in various circumstances and, by comparing them with the cost of titanium bolts and screws, indicates their application.

1. General Considerations

Broadly speaking, weight saving on aircraft already built, or to be constructed to an existing design, can be utilized in one of four ways:—

(i) To carry extra payload over the same distance.
This affords the most obvious benefits and also leads to the greatest economic gains. It is the only way considered by the S.B.A.C., B.O.A.C. and B.E.A. yardsticks.

The full, potential, economic gains often cannot be secured under this heading, but where additional payload cannot be carried or accommodated some advantage accrues in one or more of the following:—

(ii) To reduce the cost of carrying the same payload over the same distance.
(iii) To carry the same payload over a greater distance.
(iv) To increase aircraft performance.

Finally, on projected aircraft only, weight savings can also be utilized in a fifth, and much more attractive, way:—

(v) To reduce the size, weight and cost of an aircraft to carry out a given mission at a given speed.

We shall consider each of these cases separately.

2. The Carriage of Greater Payload Over the Same Distance

Greater payload is of little or no effective value on fighter aircraft (on which the armament racks are normally filled to capacity) and we shall only examine it in relation to military bombers and transport aircraft and to civil airliners.

The former may appear the simpler case, but it is actually a more complex problem of logistics. Generally speaking, the cost of a given military operation by a particular type of aircraft tends to vary inversely as the payload carried by each available machine—because, if savings in empty weight permit greater payload capacities, and the load (whether bombs or supply containers or paratroopers) is of such a size in relation to the aircraft that more can be carried on each mission, fewer aircraft are required to drop the same total weight. Although the chance of the operation being partially successful may be slightly reduced, depending on the concentration of the attack and the efficiency of the defence, the numerical casualties will also tend to be fewer. Operational Research methods are necessary to strike the optimum balance between conserving aircraft and increasing the tonnage dropped.

The corresponding case for airliners can be much more precisely calculated. The overall financial gain will be the product of three factors:—

(i) The increased revenue obtained if additional payload were *always* carried.
(ii) The percentage of occasions on which additional payload *will* be carried.
(iii) The percentage of the increased revenue which will be retained as additional profits.

* Following general international practice, "short" tons of 2,000 lb. are used throughout this study.

† K.L.M. had not introduced Viscounts by the end of 1956.

2.1.—The Potential Revenue Increase

It is convenient to use the term "Potential Revenue Increase" for the increased revenue which would be obtained if additional payload exactly replaced the reduction in empty weight. It is clearly the product of the additional payload per flight, the number of flights made and the revenue rate per pound for that distance. These factors can be conveniently rearranged thus:—

(Potential revenue increase per lb. additional payload)
=(Revenue rate per lb.-mile)×(Number of miles flown).

The first factor on the right-hand side is usually expressed in pence or in cents per ton-mile carried, or per "Load Ton-mile" (d./l.t.m. or c./l.t.m.).* This rate is usually the subject of Government or inter-airline regulations, but over a given route it may be regarded as a constant for our purpose.

The second factor is subject to wide variation. It is convenient to express it as the product of three further factors:—

(Number of miles flown per aircraft)
=(Overall ground speed)
×(Number of hours flown per year)
×(Number of years over which empty weight is reduced).

In this the overall ground speed is the "block-to-block speed" and the number of hours flown per year is the "annual utilization." The number of years over which empty weight is reduced cannot be greater than the life of the aircraft and will be less if the modification is subsequently introduced.

Introducing these factors, we arrive at the formula:—

(Potential revenue increase per lb. additional payload)
=(Revenue rate per l.t.m.)×(Block-to-block speed, m.p.h.)
×(Annual utilization, hours)×(Number of years' life).

From this it is apparent that the potential revenue increase varies directly as the block speed and as the number of hours flown per year. The first is a measure of the design of the aircraft; the second is to some extent a measure of the efficiency of the airline. The potential revenue increase is therefore greatest on fast aircraft and on routes and airlines with high annual utilization.

Table 1 shows typical values for these factors and for the resultant potential revenue increase. Data for DC-3 and Viscount aircraft—typical of obsolescent short-range piston aircraft and modern medium-range turboprop aircraft respectively—are obtainable from B.E.A. Annual Reports and Accounts. The best available data for B.O.A.C. only relate to the operation of their whole fleet in 1955-56, the last Annual Report and Accounts containing insufficient data. The latest published data are given for United Air Lines and K.L.M.†—representing highly efficient piston-engine operations, and for Trans-Australia Airlines and for Trans-Canada Air Lines—representing good mixed piston/turboprop operation. Estimates are also given for the Comet to indicate the probable results with future high-speed jets.

It can be seen that in certain circumstances the potential monetary value of 1 lb. of weight saved can exceed £1,000 over the life of the aircraft.

2.2.—The Percentage of Occasions on which Additional Payload will be Carried

We now consider the three principal conditions under which it will be possible to offer additional payload capacity:—

(i) Wherever the operating weight of the aircraft has to be restricted to ensure adequate performance. For instance, if the available runway length is too short in relation to the operational altitude and probable temperature at take-off, or if there would otherwise be inadequate clearance over a mountain pass in the event of failure of one or more engines, then the take-off weight has to be reduced, frequently curtailing the payload capacity which can be offered.

(ii) Wherever the fuel reserves are unusually high as, for instance, where there is no suitable airport close to the destination which can serve as an alternate. The strength of the landing gear often limits the maximum permissible weight of the aircraft on landing (when the greatest loads are imposed) to a figure below that at take-off; if the necessary fuel reserves are large, the maximum payload may have to be reduced. Such cases arise on the so-called "Polar Flights" via Greenland,

TABLE 1

Potential Revenue Increase per Pound Weight Saved

Airline	B.E.A.	Trans-Australia Airlines	B.E.A.	United Air Lines (U.S.A.)	K.L.M.	Trans-Canada Air Lines	B.O.A.C.	—
Aircraft	DC-3 (Pionairs and Leopards)	Whole fleet	Viscount (V700's)	Whole fleet	Whole fleet	Whole fleet	Whole fleet	Comet
(a) Average block-to-block speed .. .. m.p.h.	122.8	178.0	225.5	242.8	216.6	225.1	222	380
(b) Annual utilization .. .. hr.	1,589	2,153	2,065	2,880	2,240	2,604	2,505	3,000
(a×b) Distance flown per aircraft per year .. miles	195,029	383,130	465,491	699,372	485,197	586,270	556,076	1,140,000
(c) Revenue per load ton-mile	59.4d.	A50.4d. (40.3d.)	60.7d.	49.4c* (42.3d.)	G2.78† (62.8d.)	63.7c* (54.6d.)	63.8d.	62d.
$\frac{a \times b \times c}{48{,}000} = (d)$ Potential revenue increase per year per lb. saved	£24.13	£32.2	£58.87	£61.7	£63.48	£66.7	£73.91	£147.25
(e) Depreciation life of aircraft .. .. years	7		7	7	5		7	8
(d×e) Potential revenue increase over whole life per lb. saved	£169		£412	£432	£317		£517	£1,030
Source of data	Report and Accounts 1956/57	Annual Report 1956 and I.A.T.A. Statistics 1957	Report and Accounts 1956/57	Annual Report 1956 and I.A.T.A. Statistics 1957	Annual Report 1956 and I.A.T.A. Statistics 1957	Annual Report 1956 and I.A.T.A. Statistics 1957	Report and Accounts 1955/56	—
Notes	Based on total fleet and all services	Based on total fleet and all revenue services	Based on total fleet and all revenue services	Based on total fleet and all revenue services	Based on total fleet and all revenue services	Based on total fleet and all revenue services	Based on total fleet and scheduled services	Typical operations

* at $ 2.80=£1. † at G10.64=£1.

where the nearest diversionary airports at present authorized are in Iceland or Labrador.

(iii) Whenever the maximum payload is limited by the structural strength of the aircraft. There is always a limit to the maximum weight which can be supported by any particular wing. On some types of aircraft this figure is sufficiently low in relation to the weight of the empty fuselage and furnishings that the maximum payload is thereby restricted.‡

In each of these three cases, every pound saved in the weight of the fuselage will *always* increase the payload capacity which can be offered. Note, however, that in the last case weight saved in the wing will not increase this capacity.

There are, however, four obstacles which may prevent all this additional capacity being utilized:—

(i) Inability to book 100% payload on every flight in both directions.

This arises mainly from diurnal, seasonal and directional traffic variations and from the airline's desire to offer sufficient capacity to reduce the number of passengers turned away to a reasonable minimum except on "peak" flights.

The ratio of the load actually carried to the capacity offered for sale, i.e., the "Booking Payload," is termed the "Load Factor." It varies from over 95% on some routes at popular seasons (such as westbound across the North Atlantic in September) to 20-30% on new services over which high loads have not yet been generated. A yearly average of 55-60% is considered reasonable on routes served by several competitive airlines, and 60-65% where capacity is regulated, e.g., by bilateral agreements between Governments.

The proportion of any additional Booking Payload which will actually be utilized will not be as high as the overall Load Factor. Extra revenue will only be obtained on those occasions when the aircraft would otherwise be full: if the Load Factor is low these occasions will be few; in fact, unless the mean Load Factor already exceeds 80-90% on at least some services, there may be surprisingly little return from the additional capacity. Fortunately, however, the dividend increases with the extent of competition from other airlines and from other means of transport, and also with the diurnal traffic variation and the degree of traffic unbalance in the two directions of movement, marked variations considerably augmenting the value of weight saving.

(ii) Inability to secure additional load.

In certain instances, such as troop ferrying, the total traffic available may be limited. For our purpose this case will be ignored and traffic assumed to be capable of expansion.

It may also happen that a few pounds of extra payload is virtually unusable, e.g., the traffic only presents itself in quanta or units of definite magnitude—after all, individual passengers are indivisible—or on an aircraft which is already the lightest of the fleet, but the Booking Payload is being calculated on the heaviest.

(iii) Inability to accommodate additional payload.

‡ For instance, this is the case with most Viscount and Douglas DC-3 aircraft. It does not necessarily imply criticism, merely that the critical limit on these aircraft is reached in this direction rather than in another.

Booking Payload is often subject to a space limitation; for instance, when every passenger seat which can be fitted is already being offered for sale. This will usually be the case on short sectors and, in fact, most airlines normally adjust their aircraft and route pattern so as to offer full payload over the majority of sectors.

This is a most difficult factor to assess; it is only from a few sources that figures can be obtained. By comparing the average capacity offered on various B.E.A. aircraft with their maximum capacity stated elsewhere in the Annual Report, we deduce that the percentage of flights on which the full capacity was offered in 1956-57 varied from 92.6% on the DC-3 fleet to 96.4% on the Viscount fleet.

The resulting figure of 8% or fewer occasions on which additional payload could have been carried if empty weight had been saved is not considered representative of longer-range networks. It is believed that the overall figure for B.O.A.C. operations is between 15% and 20%; it is probably nearer 40% on critical trans-oceanic sectors.

(iv) Inability to attract more payload at the same overall revenue rate.

If all the available mail is being carried (this is the most important category of load as the airline is generally contractually obligated to its carriage; it may also be the most financially rewarding) and the full complement of passenger seats is already being offered for sale, additional revenue can only be secured at freight rates, which are lower than passenger rates on a weight basis.

2.3.—Percentage of Additional Revenue Retained as Profit

The third principal factor in determining the extra profit to be derived from the additional payload carried is the ratio of profit to revenue. Clearly, some costs will increase, such as passenger insurance and booking expenses, agents' commissions, and the many luxuries which are still being offered by many airlines to travellers who would not dream of affording them on other occasions. Although the S.B.A.C. and other operating-cost formulæ would indicate a reduction in engineering and maintenance costs through a weight saving, these costs will, if anything, tend to increase slightly.

The ratio of profit to revenue varies with the types of aircraft and traffic; for instance, long-distance services require higher standards of passenger amenities, meals and service, more extensive promotion by travel agencies, and so on. For an estimate we again refer to B.E.A. Annual Reports and find that in 1956-57 the cost of these services varied from 7.4% of revenue on domestic routes to 10.7% on international routes.

The overall gain through carriage of extra payload will therefore be 89-93% of the additional revenue obtained.

2.4.—The Increase of Profit per Pound Weight Saved

We can now combine all these factors and reach the following conclusions as to the probable extra profits from each pound of weight saved:—

(a) Wherever payload is limited by maximum landing weight or by an en-route performance limitation, every pound of weight saved anywhere on the aircraft affords a pound of additional payload capacity.

(b) On aircraft in which the payload is limited by the

strength of the wing-fuselage intersection, every pound of weight saved in the fuselage or furnishings represents a pound of additional payload capacity.

(c) In other cases, additional payload capacity can only be offered for sale on a proportion of services ranging from 25% to 40% on inter-continental routes to about 5% over a regional network.

(d) The proportion of additional payload capacity which will actually be utilized will be less than the present mean Load Factor, which may vary up to about 70%. Unless a high L.F. is being obtained on at least some services, the increase in load actually carried will be small.

(e) On most, though not all, occasions the additional payload will attract rather less than the overall average revenue rate.

(f) About 90% of the additional revenue should be retained as additional profits.

The overall proportion of the potential revenue increase which will actually be realized as profit will, therefore, vary from a maximum of 50-58% (a or b×d×f above) on long-range aircraft down to as little as 2% (c×d×f). Probable values of the additional profits realized through weight savings in four typical operations are given in Table 2.

Probable ranges correspond to ±10%. It must be appreciated that much wider variations are possible, up to factors of at least 2 or even more, depending on the utilization, the revenue rate and the general character of the airline's overall route network.

On those occasions when the whole of the potential revenue increase is not secured smaller benefits may be obtained in one or other of the three ways we shall now examine.

TABLE 2

Probable Increase in Profits Per Pound Weight Saved
(excluding savings in fuel burnt and ignoring the cost of the weight saving)

Operation	Useful life of aircraft remaining after modification			
	8 years	6 years	4 years	2 years
1. Payload limited by structure strength and/or performance	£	£	£	£
Typical long-range jet	655–800	490–600	325–400	165–200
Typical long-range turboprop	490–600	365–450	245–300	120–150
Typical medium-range turboprop	300–370	230–280	151–185	76– 93
Typical short-range piston	175–215	130–160	88–105	44– 54
2. Payload not generally limited by structural strength or performance	£	£	£	£
Typical long-range jet	165–200	120–150	82–100	41– 50
Typical long-range turboprop	98–120	73– 90	49– 60	24– 30
Typical medium-range turboprop	46– 56	34– 42	23– 28	11– 14
Typical short-range piston	18– 21	12– 16	9– 11	4– 5

3. The Lower Cost of Carrying the Same Payload Over the Same Distance

On every winged flying machine a proportion of the engine power is absorbed in providing lift, the remainder overcoming the aerodynamic drag of the wings, the fuselage and the control and stabilizing surfaces. The lighter the aircraft, the less the power required for sustentation. Hence, if additional payload is not carried a decrease in empty weight will reduce the power required for flight at the appropriate speed.

This reduction can be employed in two ways: first, as there is more power available for propulsion the aircraft can be flown faster; secondly, the fuel consumption, expressed in miles per gallon, can be improved. The potential increase of speed will, however, not be large; even in cruising flight the proportion of the total power absorbed in sustentation is never more than one-half, and it may be as little as one-sixth at high speeds, so that on fighter aircraft, where the propulsive power required increases very rapidly with speed, weight saving has virtually no effect on speed.

Weight savings will increase the speed of transport aircraft to a negligible extent except, possibly, at maximum cruising speed; in fact, if economical procedures are being used to stretch the range the speed for maximum lift/drag ratio will actually be reduced by a weight saving, but there should be a useful improvement in miles per gallon.

As a surprisingly close approximation, the fuel consumption per mile varies directly with the aircraft weight. The total fuel burnt will, therefore, be reduced by the same percentage as the fall in the average weight of the aircraft during the flight. It follows that the saving, in the weight of fuel burnt for each pound saved, is the same as the ratio of the total fuel burnt per flight to the average gross weight of the aircraft during the flight.

By suitable manipulation this can lead to a formula utilizing factors for which values are obtainable from, for instance, the B.E.A. Annual Report and Accounts.§ For 1956-57 the value of the fuel which would be saved per year through each pound of reduction of empty weight *which was not replaced by extra fuel or payload* would have been: Viscount V700, 16s. 7d. per annum per lb. weight saved; DC-3 Pionair/Leopard, 13s. 4d. per annum per lb. weight saved.

Such a saving is, of course, small. Even if something is added for reduced engine maintenance and overhaul, the saving only amounts to the cost of a few gallons wasted in spillage, and we therefore conclude that the case for titanium bolts cannot be supported on this score alone.

4. Increased Range

It might appear that there was no possibility of using increased range on an existing route network, as the sector distances usually cannot be extended by sufficiently small increments. In fact, however, this case can be important if the greater distance over which the same payload can be carried is translated into larger fuel reserves (subject to adequate tankage), reducing terminal casualties in military operations and permitting a higher average regularity in critical airline operations.

In the case of fighter aircraft, increased fuel uplifts lengthen endurance over the target area and, for instance, would have been invaluable in the Suez campaign. In airline operations more fuel permits the same payload to be carried against a stronger headwind. In some cases, for example, Stratocruiser services westbound to New York, this can significantly increase the probability of operation via the direct route and reduce the number of flights via Iceland with large savings in the distance flown.

As a matter of interest, if the additional fuel permitted by weight saving were utilized to fly the same payload farther on the *same number of flights*, substantial gains would ensue. The additional profits are not simple to calculate as not only would the total revenue increase, but maintenance, overhaul and crew costs would also go up. The net dividend from each pound of weight saved and utilized in this way** would have been about £54 per year for each Viscount and £47 for each DC-3 in B.E.A.'s 1956-57 operations.

Such a high figure may appear surprising—that for the Viscount is nearly as great as the potential revenue increase shown in Table 1 and is considerably greater than the probable extra profits obtained—until it is realized that it implies an increase in the total miles flown in a given time, and thus an increase in the work done. For each pound of weight saved which could be burnt as additional fuel on every flight a B.E.A. Viscount would fly for 27 more minutes in a year and a DC-3 2 hr. 25 min. more. It is for this reason that increased range is of somewhat academic interest in the case of short- and medium-range aircraft.

A much more useful consequence of longer range from weight saving is available wherever surface transport is difficult and therefore expensive, as in the remoter corners of Africa and South America. Substantial savings can often be made by purchasing more fuel where it is cheap.

5. Increased Aircraft Performance

The benefit from weight saving may also be taken in improved aircraft performance. This is particularly useful on fighters, where an increased rate of climb will be obtained. In fact, if expressed in terms of the research and development expenditure and effort necessary to secure an equal improvement in rate of climb, an application of titanium bolts and screws appears exceptionally attractive, particularly on naval carrier aircraft, on which take-off and landing performance is critical.

Faster climb will generally be accompanied by a higher ceiling. It can be shown that this should rise by 1,000 ft. by every 3-4% reduction in gross weight on a piston aircraft and by 1,000 ft. for every 4½% on jet aircraft operating in the stratosphere. Minor weight savings have less effect on ceiling than diurnal differences in air temperature.

Improved performance also shows up in slower take-off and

§ (Cost of fuel saved per lb. weight saved)=(Fuel costs per hour)×(Annual utilization in hours)×(Number of years life)÷(Average gross weight of aircraft in pounds).

** The B.E.A. Annual Report does not contain sufficient data to calculate this saving directly. However, provided the average engine fuel consumption is known, the following formula may be used:—
(Extra profits per year per lb. weight saved)
=(Revenue per hour−Hourly costs per hour)×(Number of flights per year)÷(Fuel consumption in lb. per hour).

TABLE 3

Approximate Cost of Titanium Bolts and Screws per 100
(as at January 1, 1958)

Shank diameter	Approximate length under head			
	1 in.	1½ in.	2 in.	2½ in.
	£	£	£	£
10-32	35–40	39–45	44–51	49– 58
¼ in. UNF	42–49	48–56	55–64	63– 74
5/16 in. UNF ..	52–61	59–69	68–79	77– 90
⅜ in. UNF	67–77	76–87	86–99	91–106

landing speeds and shorter distance, both of which make definite contributions to overall safety of every aircraft,¶ but none of these benefits is susceptible to precise calculation.

6. Augmented Economic Benefit

Hitherto, we have considered cases where each pound saved represents the only loss of weight. Leaving for the moment the consideration of new aircraft (see Section 9 below), there are some cases of considerable practical importance in which the effect of a particular weight saving is immediately multiplied by consequential changes elsewhere. An instance is where the maximum payload is limited by the trim or balance of an aircraft, preventing the rear baggage hold being filled to its full capacity; every pound of weight saved on the tail surfaces will then permit the carriage of more than one pound extra freight. Another example is found in engine design. If connecting rods on piston engines were made of titanium alloy, their lighter weight would be reflected in lighter balance weights on the crankshaft, thus approximately doubling the effect of the weight saving.

Other cases occur wherever there are highly stressed rotating parts. Use of titanium bolts on helicopter rotor arms would appear particularly attractive, in that they also reduce the critical loads on the rotor hub.

Instances are not restricted to design. Weight saving on the heaviest aircraft of a fleet may permit a higher payload capacity to be offered throughout the fleet yet avoiding booking difficulties; it may well outweigh the inconvenience of having aircraft of two different standards in a given fleet.

These special cases need not, however, be considered in arguing the general application of titanium bolts and screws.

7. Titanium Bolts and Screws

Designers accustomed to the relative cheapness of mild-steel nuts and bolts may well be surprised at the apparent expense of their titanium equivalents. Table 3 gives figures prepared by Guest, Keen and Nettlefolds, Ltd., of initial production prices in their titanium-bolt project for some typical sizes in large demand.

For our purposes these figures can be presented in a more useful manner by combining them with the fact that titanium bolts weigh about 57% of the equivalent 55-ton steel bolts. Table 4 shows the approximate cost of weight saved by such a direct substitution. It will be noticed that this cost increases with reduction in length and increases considerably with reduction in diameter. It is clear that for some time to come the use of short, small-diameter, titanium bolts may be limited.

From an accounting point of view, it is not necessary to recover the whole of the cost of weight saving over the depreciation life of the aircraft. It is standard practice to write down book values of aircraft and spares to figures representing realistic disposal prices. K.L.M. still depreciates down to 10%, but the Civil Aeronautics Board now requires U.S. airlines to depreciate only down to 15%, and both B.O.A.C. and B.E.A. have adopted 25%.

8. Application to Existing Aircraft

We may now compare the cost of weight saving by titanium with the increase in profits. Table 5 shows the probable net return for four typical operations for various periods over which a weight saving is effected. It will repay study.

It is believed that the values given in this table are conservative and enhanced profits may well be achieved even in normal circumstances. In special cases, such as on the heaviest aircraft of a fleet, the economic value of any weight saving may well be increased by a large factor.

¶ The economic gain from weight saving on sectors where the payload is limited by take-off or landing runway requirements is the same as that given in Section 2 (on pp. 294-296).

As with Table 2, wide variations in the indicated values will result from exceptional utilizations or over an unusual network.

9. Application to Future Aircraft Designs

The case we have shown to exist for the adoption of titanium bolts and screws on existing aircraft is greatly strengthened on future aircraft, which can be designed from the start to incorporate titanium bolts and screws. Here we may make use of the so-called "Growth Factor" devised by Mr. E. H. Heinemann, chief engineer of the El Segundo Division of the Douglas Aircraft Co. In a classic lecture in 1952 (Ref. 2) he showed that every pound of weight added to any accessory or component caused a many times greater increase in the total aircraft weight if the same overall performance was to be obtained in achieving the same mission. He termed this the "Growth Factor" and gave 10 : 1 as an average value.

TABLE 4

Approximate Cost of Weight Saving by Replacing Steel Bolts and Screws by Titanium
(Allowance made for cost of steel bolts and screws)

Shank diameter	Approximate length under head			
	1 in.	1½ in.	2 in.	2½ in.
	£	£	£	£
10-32	94–110	70–82	61–72	55–64
¼ in. UNF	59– 70	47–56	42–49	39–46
5/16 in. UNF ..	46– 54	36–43	33–39	31–36
⅜ in. UNF	40– 47	32–38	28–33	25–29

Summary of Above Figures

	No. per a/c.	Potential weight saving
		lb.
De Havilland Comet	41,721	284.0
All-weather fighter	20,028	119.4
Naval strike fighter	7,760	63.0

Conversely, it follows that any weight saving in the initial design stages can result in a many times greater reduction in the total weight of an aircraft to carry out a given job at a given speed and, therefore, in its size and cost. Usually the same engines must be selected, in which case the same mission will be completed faster, yet with a smaller and lighter and cheaper aircraft.

A short calculation will show the effect of the growth factor on the case for titanium-alloy components throughout new aircraft. Modern British civil aircraft cost between about £4 per lb. of empty structure weight (excluding powerplants and instruments) for small aircraft, and up to £8 per lb., or even £12 per lb., on large pressurized aircraft, in which the design and tooling costs are high in relation to the total production. The corresponding costs per pound of gross weight range from £3 to £7 10s. Since each pound saved by the use of titanium bolts can be multiplied by a Growth Factor of 10, the value of such weight saving to the manufacturer may, therefore, be as high as £75, resulting in a net decrease in aircraft price.

Comparable costs cannot be simply stated for military aircraft as so much of the total expenditure is borne on development contracts rather than on production orders, but we may usefully quote Mr. Heinemann himself:—

> "Each pound of weight added, when multiplied by a growth factor of 10 and a cost factor of $40 per lb., causes a $400 increase in airplane cost if performance, range and strength remain constant. This $40 is a cost factor arrived

TABLE 5

Probable Net Return per Pound Weight Saved by Titanium Bolts
(assuming Titanium bolts at £55 per lb. weight saved, less 20% residual value on disposal of aircraft)

	Useful life of aircraft remaining after modification			
	8 years	6 years	4 years	2 years
1. Payload limited by structural strength and/or performance	£	£	£	£
Typical long-range jet	610–755	445–555	280–355	120–155
Typical long-range turboprop	445–555	325–405	200–255	78–105
Typical medium-range turboprop	260–325	185–235	110–140	32– 49
Typical short-range piston	130–170	88–115	44– 63	up to 10
2. Payload not generally limited by structural strength or performance	£	£	£	£
Typical long-range jet	120–155	79–105	39– 57	up to 7
Typical long-range turboprop	55– 77	30– 47	6– 17	
Typical medium-range turboprop	3– 13	NET LOSS		
Typical short-range piston				

TABLE 6

Quantities of Bolts and Screws Required and Potential Weight Savings by Titanium

Shank diameter	No. 10 or 2BA.		¼ in.		5/16 in.		⅜ in.		7/16 in		½ in.		⅝ in.	
	No. per a/c.	Potential weight saving	No. per a/c.	Potential weight saving	No. per a/c.	Potential weight saving	No. per a/c.	Potential weight saving	No. per a/c.	Potential weight saving	No. per a/c.	Potential weight saving	No. per a/c.	Potential weight saving
		lb.		lb.		lb.		lb.		lb.		lb.		lb.
De Havilland Comet ..	19,637	71.9	18,378	137.7	2,938	45.3	727	24.5	26	1.5	14	2.8	1	.3
All-weather fighter ..	10,459	31.6	7,134	46.3	1,852	24.2	423	10.2	42	1.5	118	5.6		
Naval strike fighter ..	3,088	11.8	3,882	35.1	415	6.0	353	9.1	22	1.0				

at through many years of experience and is substantiated by the report 'Survival in the Air Age' (Finletter Report for 1948). This cost represents experimental and production costs and is based upon gross weight, including Government-furnished equipment. It is rather arbitrary but, if anything, conservative. Recent spot-checks have shown that present costs are more likely to be nearer $50 per lb. Current statistics are not available to determine the actual costs. Nevertheless, it is recommended that designers and procurement agencies use a factor of $40 per lb. as a guide in evaluating design decision."

Since that time (1952) these costs have increased. There is also evidence that the Growth Factor rises with increased complexity and performance. Two years later Mr. Heinemann quoted the following values (Ref. 3): Piston-engined fighter (type AD: first flew 1945), 4.3 : 1; twin-jet fighter (type A3D: first flew 1952), 8.0 : 1; twin-jet delta-wing fighter (type F4D: first flew 1951), 10.0 : 1. And he predicted that it might rise to 15 : 1 on supersonic aircraft.

The case for the adoption of titanium bolts by manufacturers of new aircraft in the preliminary design stages seems very strong.

10. Scope for Titanium Bolts and Screws

Finally, it may be of interest to quote figures for the number of bolts and screws on certain representative aircraft which have been worked out by the manufacturers concerned. These are given in Table 6. The totals may appear surprisingly high:—

	Number of Bolts and Screws per aircraft. (Sizes between No. 10 and 5/8")	Potential Weight Saving by Replacement of Steel by Titanium
De Havilland Comet..	41,721	284 lb.
All-weather fighter ..	20,028	119 lb.
Naval strike fighter ..	7,760	63 lb.

11. Conclusions

This study leads to the following conclusions regarding the economic application of titanium bolts and screws:—

(1) Operators of long-range aircraft should find it well worth while to employ them extensively, even if there is only a limited life of the aircraft remaining before disposal.

(2) Operators of medium-range aircraft should find it well worth while to employ them, particularly in the larger sizes and in the early stages of the aircraft's life.

(3) Except in special circumstances, their cost may not be justified for operators of short-range aircraft.

(4) Wherever the payload is limited by structural strength or performance they will be well worth while adopting on all classes of aircraft, even on the shorter ranges when only a few years' life remains.

(5) They appear to be a particularly attractive means of offsetting the steady increase in empty weight over the life of an aircraft and thus avoiding any reduction in payload capacity and/or regularity.

(6) Special cases exist, particularly where rotating machinery is involved, where small weight savings are immediately multiplied, more than justifying their cost.

(7) Resultant improvement in rates of climb of military aircraft could be invaluable and would cost much less than the research and development necessary to secure an equal improvement.

(8) There is a very strong case for adopting them on new aircraft. If consideration is given to them at a sufficiently early stage in the design there may even be a net-cost saving to the manufacturer.

(9) Weight savings of over 250 lb. appear possible on large transport aircraft, and of 60-100 lb. on fighter aircraft.

References

(1) "The Financial Aspect of Weight Saving": Technical Section, The Society of British Aircraft Constructors: London, Third Issue, February 1957.

(2) "Aircraft Weight and Cost *Can* be Reduced": E. H. Heinemann, *Aeronautical Engineering Review*, January, 1953, pp. 20-23. (Based on a lecture to the Washington, D.C., Section of the Institute of the Aeronautical Sciences, October 7, 1952.)

(3) "The Design of Light-Weight, High-Performance Military Aircraft": E. H. Heinemann, Society of Automotive Engineers Preprint No. 379, New York, 1954. (Based on a lecture to the S.A.E. National Aeronautic Meeting, Los Angeles, October, 1954.)

The following may also be useful:—

(4) "Clear Design Thinking Using the Aircraft Growth Factor": William F. Ballhaus, Society of Automotive Engineers Preprint No. 377, New York, 1954. (Based on a lecture to the S.A.E. National Aeronautic Meeting, Los Angeles, October, 1954.)

(5) "The Design of Lightweight Simplified Combat Aircraft": E. H. Heinemann, Interavia, No. 3, 1955, pp. 172-178.

Re-entry of Ballistic Missiles

HOW CAN a ballistic missile or its warhead enter the atmosphere at 13,000 m.p.h. without burning up? How can it travel down through the atmosphere without being diverted from its predicted course? A fascinating discussion of the problems posed by these questions is given in two recent NACA technical notes.*

The velocity and deceleration history of a missile re-entering the atmosphere is studied. The effect of gravity is negligible compared with that of aerodynamic drag, and the missile's trajectory through the atmosphere is practically a straight line. The maximum deceleration of the missile, when this occurs before impact, is independent of missile mass, size and drag coefficient and depends only on flight-path angle and entry velocity.

For present-day missiles the peak deceleration occurs at altitude. For example, a solid iron sphere 1 ft. in diameter entering the atmosphere vertically at 20,000 ft./sec. will be subjected to a peak deceleration of about 105 *g* at 45,000 ft.; the deceleration falls off rapidly at lower altitudes.

Aerodynamic heating during descent is a vital factor in the design of ballistic missiles. The weight of coolant carried must be kept to a minimum: a saving of 1 lb. in warhead weight can save about 20 lb. in initial weight of a missile.

Total heat transfer must also be kept to a minimum. For conventional missiles blunt high-drag shapes are best, so that during deceleration as much heat as possible is transferred to the atmosphere and the minimum of heat to the missile. In this case the minimum weight of coolant is needed.

The greatest transfer of heat per unit area takes place at the missile nose. A pointed nose is unsuitable; with such a nose the heat-transfer rate is very high and capacity for retaining heat is low. Such a nose would burn away.

Nose shapes with hemispherical tips are more suitable for ballistic missiles. With these the bow shock-wave is detached and the flow around the nose is subsonic. Thermal stress is minimized by using a blunt shape having the largest possible tip radius and overall drag. Sweat cooling can be used to minimize the heat-transfer rate and thus the thermal stress.

A suitable shape for the re-entry missile is the sphere. It has

* **NACA T.N. 4047.** "A study of the motion and aerodynamic heating of missiles entering the Earth's atmosphere at high supersonic speeds," by H. Julian Allen and A. J. Eggers, Jr. **NACA T.N. 4048.** "Motion of a ballistic missile angularly misaligned with the flight path upon entering the atmosphere and its effect upon aerodynamic heating, aerodynamic loads and miss distance," by H. Julian Allen.

the advantages of a high-drag shape, maximum volume for a given surface area, an inherently stiff and strong surface and a large stagnation-point radius. Aerodynamic forces on it do not vary with attitude and it needs no stabilizing surfaces.

It can be rolled during flight so that the surface is heated uniformly.

The high-drag sphere has some drawbacks, however. A low terminal speed enables effective counter measures to be taken. Lower descent speed increases wind-drift error at the target, and its high drag may give a maximum deceleration greater than desired.

These disadvantages can be minimized by a specially cooled spike protruding from the front of the sphere, which must then be stabilized. The spike induces flow separation and reduces the drag coefficient by about a half.

A missile is likely to enter the atmosphere when it is tumbling or out of line with its flight path. It is essential that it should have only one trim attitude and that this should be reached before it has travelled far through the atmosphere and has become subject to extreme heating and to large deceleration loads. This can be done by disposing of its empty fuel and oxidant tanks after it has entered the atmosphere and taken up a stable attitude.

Studies show that if a missile enters the atmosphere out of alignment with its flight path, its oscillations will be continuously damped to zero as it descends. The normal accelerations imposed on the missile are not excessive.

The miss distance when a missile enters the atmosphere out of alignment with its flight path is negligible. For a 20° divergence it is only plus or minus 10 ft.

But the miss distance because of trim angle is very great; a trim angle of even 0.1° can cause an error in range of many miles. Measures must be taken to minimize this inaccuracy by spinning the missile about its axis so that it follows a corkscrew course during descent. The spin rate must not approach the pitching or yawing frequency or the missile may tumble.

Something New in VTOL

ONE OF the many interesting layouts for VTOL aircraft now being investigated in the U.S. is that of the Doak Model 16 research type. This has a pivoting ducted propeller at each wing tip and is, therefore, in the propeller-driven flat-riser category of VTOL machines.

Apart from the tip-mounted ducted propellers, the Model 16 is a more-or-less orthodox aeroplane with fixed wing and tail surfaces having hinged control surfaces at their trailing edges. A crew of two is seated in tandem and there is a nosewheel undercarriage.

As is the case with other propeller-driven VTOL research craft—the Vertol Model 76 (which has now flown both vertically and horizontally, but has not so far made transitions) and the Ryan Vertiplane—the Doak Model 16 has a single Lycoming T53 shaft turbine of 825 s.h.p. in the fuselage. The ducted propellers are shaft-driven through the wings and, for vertical take-off and landing, are in the plane of the wings. After take-off the ducts are swung through a right-angle to give thrust for forward flight.

The Doak design can operate in this manner as a VTOL type, but it can also be used as an STOL type where there is a small runway available—thereby converting its configuration more quickly to that required for normal flight and allowing the fitment of extra fuel tanks for longer endurance because of the lift produced by the wings during take-off.

The ducted propeller layout has been investigated by the NACA and several projects have been proposed—notably by Bell for commercial and assault transports based upon their projected D-182A research type. The Doak design is the first to be built—under a U.S. Army contract—and ground testing was due to begin on February 25.

This impression shows the Doak 16 in three aspects of flight: rising vertically; with the propeller ducts rotating towards the horizontal position, and (at top) with the propellers horizontal and the aircraft in forward flight.

A Pioneer of Air Power

THE death of Air Vice-Marshal Sir Charles Longcroft, K.C.B., C.M.G., D.S.O., A.F.C., occurred in London on February 20. He was 74.

In the early days of flying he earned for himself a high reputation both as a pilot and for the intelligence he applied to the many problems which arose on military aviation. After education at Charterhouse and Sandhurst he was commissioned, in 1903, in the Welch Regiment, learning to fly seven years later and gaining Aviator's Certificate No. 192. He was attached to the Air Battalion of the R.E., and in July, 1912, became a Flg. Off. in the R.F.C. By the spring of 1914 he was a squadron commander and temporary major.

He was among the pilots who took part in the big Army manœuvres of September, 1912, and gave an effective demonstration of the value of aircraft for reconnaissance. About this time he was making (for those days) some long-distance flights in a B.E.2 and one of them—non-stop from Montrose to Farnborough via Portsmouth, on November 22, 1913—resulted in his being the first recipient of the Britannia Challenge Trophy, which had been instituted by the R.Ae.C. Longcroft took 7 hr. 20 min. for the flight.

At the start of the First World War, Longcroft went to France with No. 2 Squadron, and soon after was given command of No. 4 Squadron. In this capacity he participated in artillery-observation work in several battles, but in the following spring was recalled to the United Kingdom to help in reorganizing the training of pilots to relieve the strain on the C.F.S.

By the summer of 1916 he was back in France, having been promoted to Wg. Cdr., and commanded No. 2 (Corps) Wing in the 3rd Brigade, R.F.C., which played a prominent part during the Somme battles.

After the War, having received, in addition to British decorations, the Russian Order of St. Stanislaus, 3rd Class, with swords, and having been made a Croix d'Officier of the Legion of Honour, he received a permanent commission in the R.A.F.

He was, for the next four years, the first Commandant of the R.A.F. Cadet College at Cranwell and played a big part in developing that body to a status which eventually equalled that of Sandhurst and Woolwich.

In 1924 Longcroft, having become an Air Vice-Marshal, was appointed Director of Personal Services at the Air Ministry, and from 1926-29 commanded the Inland Area. He was placed on the retired list at his own request in 1929. From 1932 to 1948 he was Gentleman Usher of the Scarlet Rod of the Order of the Bath, after which he became registrar and secretary of the Order. He was president of the Aerodrome Board in 1934-35 and was promoted K.C.B. in 1938.

(*Continued from page* 279)

W.R.A.F. TOUR.—Air Cdt. M. H. Barnett, Director of the W.R.A.F., left London on February 21 for a tour of M.E.A.F. She will be visiting W.R.A.F. personnel stationed in Malta, Cyprus and Aden before returning to the U.K. on March 8.

U.S. TRAINING AID.—The U.S. Government has granted scholarships for 10 Mexican Air Force pilots to be trained on jets. After their training Mexico will acquire some jet-propelled aircraft under an agreement by which the U.S.A. is to make a loan of $10 million for armament purposes.

S.A. DEFENCE.—Mr. F. C. Erasmus, South African Minister of Defence, announced recently that regular air patrols of the Union's northern boundaries have been organized. They are eventually to be extended to the boundary between Punda Maria and the Caprivi Strip. Mr. Erasmus has been quoted as saying that one of the good results of the Sputniks has been that new life is infused into NATO; and he welcomed the recent British announcement that separate military commands would be organized in Aden and East Africa.

NO. 33 SQUADRON.—The date of the Standard presentation to No. 33 Sqn. at R.A.F. Leeming (THE AEROPLANE, February 14), originally planned for April 17, has been postponed until April 24.

R.A.F. APPOINTMENTS.—Air Cdre. H. W. Mermagen has been appointed Air Officer in Charge of Administration, Transport Command. A.O.C., R.A.F. Ceylon since May, 1955, he commanded the Central Gunnery School at Leconfield from 1952 to 1954. The A.O.C. Hong Kong, since July, 1955, Air Cdre. A. D. Messenger, has become Director of Manning at the Air Ministry.

MARITIME EXERCISE.—Four Coastal Command Shackleton M.R.2s of No. 120 Sqn. are to take part in joint sea/air exercises next month with British and Canadian maritime forces during the Home Fleet Spring Cruise. Operating from R.C.A.F. Greenwood, Nova Scotia, the detachment will be commanded by Wg. Cdr. G. Buckle, D.C., No. 120 Sqn.

News About People

Photograph copyright "The Aeroplane"

R.A.E. PRIZEWINNERS.—Recipients of awards at the R.A.E. Technical College's annual prize distribution on February 21 were, left to right: J. B. Hargrave; C. F. M. Glanister; T. J. Roberts; J. A. B. Wills; M. B. Peel; Sir Alexander Fleck (who made the presentations); and R. C. S. Onslow.

SHORT-HAUL PROBLEMS. — On Tuesday, March 4, Mr. D. O. Manning, of British European Airways is giving a paper on "Commercial Aspects of Short-haul Air Transport" to the North Western Section of the Institute of Transport. It will be given in Manchester's Town Hall Annexe, starting at 18.15 hrs.

MEXICAN DESIGNER.—Ing. Angel Lascurain y Osio, Mexican aircraft designer, was killed in an aeroplane accident on December 24 last. He had built aircraft for the Mexican Air Force since 1920 and his latest was the Aura 14-seat twin-engined monoplane intended for domestic airline use.

APPRENTICE OCCASION.—Prize-winners and officials attended the Armstrong Siddeley Motors, Ltd., apprentices dinner on February 14. Front row, left to right, are Mr. P. Davenport (best craft apprentice); Mr. C. Phillips (education and training officer); Mr. A. Stevens (best all-round apprentice for the year); Mr. H. T. Chapman (managing director, Armstrong Siddeley Motors) and Mr. R. Carey.

YEOVIL VISIT.—The Rt. Hon. The Earl of Selkirk, First Lord of the Admiralty, visited Westland Aircraft, Ltd., on February 21. He made a tour of the assembly shops and saw the Whirlwind H.A.S. 7 production line as well as inspecting the Wessex.

HELICOPTER TALK.—Mr. Leonard Thornhill, of Westland Aircraft's sales department, is to talk on "Helicopters and their Uses in Africa," to the London Society of Air-Britain at Caxton Hall, London, S.W.1, at 19.00 hrs. on March 5.

B.G.A. BALL.—The guest of honour at the British Gliding Association Ball on March 14 is to be the Polish Ambassador in London, H.E. Eugeniusz Milnikiel. The Ball will be held in Londonderry House, 19 Park Lane, London, W.1, from 20.30 hrs. until 02.00 hrs.

Air Vice-Marshal C. D. Candy, C.B.E., is the new A.O.C. of Home Command, R.A.A.F. He took over his duties last week.

GUILD TROPHIES.—The G.A.P.A.N. has awarded the 1957 Cumberbatch Trophy to Malayan Airways; the Derry and Richards Memorial Medal for 1957 goes to Mr. Michael Randrup, Napier chief test pilot. These awards will be presented at a banquet in London on May 28.

MR. J. H. CORK.—We regret to record that Mr. John H. Cork, manager of the aircraft laboratories of Vickers-Armstrongs (Aircraft), Ltd., died on February 9. He was 55. He joined Vickers in 1923, and had held his last appointment for 20 years, being closely concerned with structural engineering of the Viscount, Valiant and Vanguard.

MR. A. F. JOHNSON.—We are sorry to hear of the death, at the early age of 49, of Mr. A. F. Johnson, C.B.E., D.F.C., who had been engaged on public relations duties and publicity for the Guided Weapons Division of the English Electric Co., Ltd. He served in the R.A.F. from 1924 to 1954.

PRIVATE FLYING

H.J.C.'s Club Commentary:

Plymouth Anniversary Dinner

Flying in Mexico

A Neat American Aircraft

● CERTAINLY one of the most successful functions in the history of the **Plymouth Aero Club** was the dinner/dance held at the Moorland Links Hotel in Yelverton on February 14. No fewer than 96 members and their guests attended to commemorate what was, in fact, the 30th anniversary of the club's foundation.

The toast, "Plymouth Aero Club," was proposed by Mr. S. Lloyd-Jones, the town clerk, who said that the club was older than the aerodrome itself, having been founded in 1928, although the municipal records do not reveal the establishment of the aerodrome as such until 1932. He paid warm tribute to the work that had been done at Roborough, and to the number of pilots trained there who served with distinction with the R.A.F.

In reply, the airport manager, Mr. W. H. W. Lucas, outlined some of the difficulties which beset aero clubs, and said that the prosperity and unity of the Plymouth club owed much to its chairman, Sir Arthur Holsely, who was unfortunately absent through illness. "Clubs and their operating companies," said Mr. Lucas, "have always had a hard struggle for existence, but the spirit and enthusiasm of all members is refreshing."

CLUB OCCASION.—At the Plymouth club dinner/dance on February 14 were, left to right, Mrs. Saye, Mrs. Lucas, Mr. Lucas, A.V.M. G. I. L. Saye, Mr. Dermot Fitzgerald, Capt. Sir John Walsham, Lady Walsham and Mrs. Fitzgerald.

● HE DREW comparisons with 25 years ago, when the membership was 34, and 300 hr. were flown in one year; at present the membership is 420, and in the past year 3,229 hr. were flown. The club had been stimulated by the training of midshipmen of the Britannia Royal Naval College at Dartmouth.

The toast to "The Guests" was proposed by Mr. S. Edgecumbe, a club member of very long standing, who extended a particular welcome to some of the more prominent guests, and said that the City of Plymouth was a pioneer in the municipal ownership of airports. The response was made by Air Vice-Marshal G. I. L. Saye, A.O.C., No. 19 Group, R.A.F., who recalled the days when, as a Flt. Lt. at Mount Batten on flying-boats, he came to Roborough to fly "those things with wheels on," and mentioned how well the club had served the R.A.F. and R.N.

The club's vice-president, Mr. Dermot Fitzgerald, presided. Among the guests were Capt. Sir John Walsham, Bt., commanding the R.N. Engineering College at Manadon, and Lady Walsham; Cdr. T. M. B. Little, from Dartmouth, and Mrs. Little; Cdr. G. F. A. Trewby, also from Manadon, and Mrs. Trewby; Wg. Cdr. R. J. B. Pearse, managing director of Exeter Airport, and Mrs. Pearse; and Mr. Dennis King, chairman of the Exeter Aero Club, and Mrs. King.

The C.F.I. of the club is Mr. Philip Cleife, who kindly supplied this account.

● OUR Mexican correspondent writes that that country's national club, the Club Aereo de Mexico, is to stage the seventh annual Mexico-Acapulco air race for private aircraft on March 1. The winner will receive the Presidente Ruiz Cortines Trophy, presented by the President of the Republic. About 50-75 aeroplanes usually enter.

The F.A.I., incidentally, has just confirmed the height record, Class C.1c, set up by Luis Struck, who, on October 18 last, flew a Helio Stratocourier (340-h.p. Lycoming) to 30,984 ft. in Mexico.

● PRIVATE FLYERS may like to note the dates of the R.Ae.C. annual air rallies to La Baule and Deauville. They are to be held respectively over the week-ends of June 28-30 and July 5-7.

An American First Effort

SEEN AT the recent International Air Show and Exposition at Miami was this trim-looking monoplane, the first attempt at home construction by Mark Horn, of West Palm Beach, Fla., who operates the Everglades Flying Service. Known as the "Lil' Trouble," it was completed in 1953 after 2½ years of spare-time work. Parts from several other types were used, including a cut-down Monocoupe wing, an Aeronca Defender cabin section, Cub landing gear and Taylorcraft wheels and brakes. The landing gear was further strengthened by the addition of Aeronca struts, and the wings are supported by inverting the original Monocoupe struts.

The engine is a 90-h.p. Continental, which can produce 100 h.p. with 100-octane fuel through modifications made by Horn. C85 pistons are fitted and changes were made to the carburetter, timing and crankshaft. Extra-duty valve springs are used, and the engine has turned at 3,450 r.p.m. with normal temperatures. A McCauley 71-51 propeller is fitted, and there is a 10-U.S.-gal. fuel tank.

The "Lil' Trouble" is fully aerobatic. Horn estimates that it cost about $1,500, excluding labour. Although basically a single-seater, dual controls are fitted behind the seat, and Horn says that a 90-lb. boy could be carried and taught to fly. There is room for 30 lb. of baggage.

DIMENSIONS.—Span, 17 ft. 10½ in.; length, 17 ft.; height, 5 ft. 4 in.; wing chord, 5 ft.

WEIGHT.—Empty, 910 lb.

PERFORMANCE. — Normal cruising speed, 165 m.p.h.; economic cruising, 145 m.p.h. (6.2 g.p.h.); stalling speed, 80 m.p.h.; ceiling, 12,500 ft.; climb, 1,700 ft./min.; take-off distance to 50 ft., 2,000 ft.; landing run, 300 ft.

Levy-Shipp photograph

GLIDING NOTES

EIGHT fire-engines occupied the grounds of the Garden House Hotel, Cambridge, on February 15, the day of Cambridge University Gliding Club's annual dinner. But, although 15 bedrooms had been put out of action by fire and supersaturation, the dining room had failed to feed the thermal, so was still available to feed the guests.

This was one of the years in which not only was the winner of the Brunt Trophy known when the time came to present it, but the trophy itself was actually available for presentation. It was offered by Sir David Brunt, former Professor of Meteorology at Imperial College, for the greatest altitude flight made each year by an undergraduate member of a University Gliding Club, the idea being that undergraduates cannot spare the time for long-distance flights. So far the only clubs in the running for it have been Cambridge and Imperial College, and hitherto Cambridge has always won it, as pointed out by Frank Irving, who came from Imperial College to present it—"an effigy of a somewhat outmoded glider with a considerable amount of yaw," as he described it.

John Griffiths was the 1957 winner with a climb of 5,100 ft. at the Long Mynd on June 18, and he also won the "mug for defying gravity" with a duration of 4 hr. 19 min. Peter Neilson won the "Machin Mug for going nowhere by the most tedious route" with a 130-mile triangle, and the prize for the fastest flight between Cambridge and Oxford, which he did at 60 m.p.h. on May 26; he is also uppermost on the "President's Ladder."

Nick Goodhart, proposing the toast of "The Club," remarked on the airways restrictions which have to be imposed because, as he put it to his gliding audience, "there are these madmen in airliners who don't know where they're going and someone has got to do something about them!" There is some hope that, as the airways tops are going up from 11,000 ft. to more than double that figure, their bases may be raised, too, possibly from 3,000 to 5,000 ft., which would make a big difference to sailplane pilots. He is, by the way, still looking for a crew member for his team in the Internationals.

Next day, February 16, the thermals around Marshalls' aerodrome were unusually strong in an air stream which had come all the way from Spitzbergen on a journey during which a lot of heat must have been put into its bottom layers without warming the top. Siegfrid Neumann, in the T-21b "Bluebell," found 20 ft./sec. lift in thermal "streets" which were forming at 13.00 hrs. before the clouds had similarly built up into streets; he even climbed outside a cloud, well above its base level, finding lift between its sunlit (S.S.W.) and upwind (W.N.W.) aspects.

William V. Menkevich, an American air gunner who has negotiated an extra two years' stay in England specially to continue gliding with the Cambridge Club, set off in the Olympia under a cloud street for his first cross-country flight and made 20 miles to Clare. But around 15.00 hrs., which was 2¼ hr. before sunset, the clouds went dead.

Meanwhile, on the same day, the Midland Club was finding strong thermals and cloud streets in the morning and around mid-day; but there, again, they petered out early. However, they were replaced by waves in which John Anstey in his Skylark reached 10,400 ft. a.s.l. and the T-42b "Eagle" went up to 9,000 ft.

* * *

LASHAM'S latest newsletter foretells the employment of a third full-time instructor this year, and yet another one for the summer months; possibly, also, a full-time winch driver. The Surrey Club has ordered a Skylark 2 and the Army Club is replacing its T-21b "Rudolf" with a T-42 Eagle. Two Eagles will then make possible a scheme "for those who can afford to pay a little more for their training but who cannot afford to spend all day waiting for their turn to fly"; this should please Sir Roger Conant, M.P., who has advocated such a scheme as a means of getting people bitten by the gliding bug who (the people, not the bug) could be useful to us in high places.

A soaring rally at Lasham is fixed for Whitsun.

* * *

IN looking forward to the Midland Gliding Club's usual inter-club rally at Easter, from April 4 to 8 inclusive, we should also look back an equal distance to an outstanding wave day at the turn of the year, news of which seems to have got overlooked in the Christmas rush. This was Sunday, December 29, when John Holder, in a Skylark 2, reached 14,500 ft. a.s.l., a height which has rarely been exceeded in wave flights over England.

Holder started off under a kidney-shaped cloud aligned roughly parallel with the Long Mynd, which lifted him to a mere 6,000 ft. But at its northern end this cloud joined up with another one, differently orientated, which was obviously marking the fourth lee wave set up by Snowdon, 62 miles to the N.W., as three other wave clouds could be seen upwind of it. This was the only wave formation shown by a layer of strato-cumulus between 3,500 and 4,500 ft. But there were lenticular clouds at about 25,000 ft., and Holder was going merrily up towards these at 5 ft./sec., when he felt symptoms of oxygen shortage—not, apparently, due to altitude, but because his clear-vision panel had frozen up and he was consequently re-breathing his own exhalations.

On the same day, Bruce Bowdler took the club's Eagle (T-42) up to 12,500 ft. a.s.l., and John Stanley, R.N., went to 9,500 ft. in the Army Club's Skylark during a 5-hr. flight.

According to Liverpool radio-sonde, the only stable regions were an inversion of 2° C. between 4,600 and 5,700 ft., an isothermal layer from 11,000 to 12,000 ft., and another inversion of 4° C. from 18,000 to 20,000 ft. The wind increased with height except for a decrease from 57 to 53 knots between 12,000 and 14,000 ft., with practically no change of direction.—A. E. SLATER.

CORRESPONDENCE

Backward-facing Seats

From Air Cdre. Sir Vernon Brown, C.B., O.B.E., M.A., F.R.Ae.S., R.A.F. (Retd.).

DURING a lecture to the Royal Society of Arts on "Safety in the Air," on March 1, 1954, I said:

> ". . . Nevertheless, the provision of an adequate belt or harness for small children or for people of abnormal shapes and sizes raises a lot of difficult problems, and I am certain that if seats were constructed to withstand at least 20g, and if, in addition, they faced backwards and were provided with adequate head, back and leg protection, the mortality figure would, in the case of survivable accidents, be reduced to an almost negligible quantity. I feel very strongly about this. . . ."

The passing of four years has in no way altered my views.

There is no doubt that the fare-paying public are becoming more and more restive about this and recently I have been asked many times why there is so much resistance to the idea. You, sir, have all the answers to that question.

But how many people know why it is so difficult to obtain the evidence which is necessary in order to build up statistics on the subject? If you will be good enough to give me space I would like to say something about this.

The job of the Accidents Investigation Branch of the Ministry of Transport and Civil Aviation is to find the cause of an accident and to make recommendations. If the A.I.B. tries to collect supplementary data about injuries, it can be accused of attempting to carry out a "splinter" investigation, which is beyond its terms of reference. That is, in fact, what happened to me some years ago when I tried to do this as an exercise. Let me mention three of the fundamental difficulties.

First, the occupants of a crashed aeroplane have always been removed before the Accident Inspector has reached the scene. Secondly, until seats are numbered and reserved it will never be possible, after a crash, to find out who was sitting in which seat—and, thirdly, doctors are bound by professional etiquette not to part with information to people who are not members of their profession, and A.I.B. Inspectors have certainly often found it difficult to obtain the medical evidence required.

I believe that from an analysis of R.A.F. accidents enough information could now be obtained to show that in survivable accidents the death, or serious injury, rate proves the advantage of aft-facing seats by something of the order of 4 to 1.

It would be most helpful to know how many of the 22 survivors of the Munich accident were seated in the backward-facing seats of the Elizabethan, and how many of the occupants of those seats were killed.

St. James's, London, S.W.1. VERNON BROWN.

Bomber Crews and Bombing Errors

THE remarks on the provision of flashbombs and cameras in bomber aircraft, made in Air Marshal Sir Robert Saundby's article "Photography's Indispensable Part" (February 14, 1958), apparently do not refer to Bomber Command as a whole.

Entries in my pilot's flying log book during service with

No. 103 Squadron show that No. 1 Group was taking night photographs by flashbombs, from May 10, 1941, onwards. The decision to equip our Wellingtons with cameras must have been taken some considerable time before that date—instead of early 1942, as quoted in the article.

Sir Robert does his bomber crews less than justice by suggesting that they did not know that much of their effort was wasted, and that such knowledge would hardly have encouraged them.

The fact is that we were given every opportunity and encouragement to study the results of our bombing. Day and night photographs, and large-scale maps of target areas and surrounding country, with the bomb craters plotted on them, were provided for this purpose.

This knowledge was a natural incentive to get better results and was as necessary to the bomber crew, as the spent target is to the rifleman, so that he can see his errors and learn to get the best from his weapon.

Shoreham, Sussex. J. R. ANDERSON.

Another Gnome

WITH reference to "What's in a Gnome?" by D. G. in THE AEROPLANE of February 7, I don't think it would be an exaggeration to say that the whole aircraft industry is founded on that wonderful old Gnôme rotary engine which, by reason of its very low weight per horsepower, did more than anything else to benefit aviation in the early days before the 1914-18 War.

Many old pilots must remember with nostalgic affection that clattering, noisy, castor-oil-slinging contraption that used to buzz behind their ears in the early pusher biplanes, its only control being the ignition switch.

In my opinion de Havillands couldn't have found a better name for their new engine, the worthy descendant of a very gallant ancestor.

Saltash, Cornwall. "A.P.F."

Home-made Helicopter

ONE answer to Maj.-Gen. H. J. Parham's interesting letter in THE AEROPLANE of February 7, for a modernized Autogiro, aye, and an ultra-light one, is the Bensen Gyro-Copter described in your issue for January 24 last.

If any of your gentlemen or lady readers are interested, in an amateur capacity, to form an English group for constructing a home-made model on a share basis, I would be glad to hear from them by letter to address below.

34 Curzon Road, London, N.10. D. USHER.

Light-aircraft Aesthetics

YOUR correspondent, Mr. L. G. Cooper (THE AEROPLANE, February 7), suggests that amateur-built aircraft are (a) ugly, (b) much over-rated, and (c) offer no advantage over the Chipmunk.

As the constructor of an aeroplane which no doubt falls into Mr. Cooper's "ugly" class, I must hasten to point out that I have never suffered delusions about the performance of ultra-light aircraft. One can hardly compare a present-day amateur aircraft of the types to which Mr. Cooper refers with a Chipmunk. The machine which I built [A Luton Minor.—ED.] would get off the ground, slowly; ascend into the sky, slowly; transport me, slowly, from A to B if prevailing weather conditions were right, and then land, once more, slowly. I personally could wish for little more from a safe, simple machine.

The idea of sporting flying, which is rapidly becoming buried, is to get into the air cheaply and without frills. It is exhilarating to put a Chipmunk "through the book"—for something like £5 an hour. It is equally satisfying to fly for almost half an hour on one gallon of petrol in a machine you yourself have created.

Concerning the proposed "fabulous" cost of a factory-produced ultra-light, it must be remembered that wooden construction does not lend itself to rapid mass-production. You cannot stamp out a wooden wing rib on a press.

Mr. Cooper goes on to say that the days of "if it looks right, it flies right" are passed. Are we really thinking nostalgically of those "good old days"—or are we thanking ourselves for having survived to advance technically since the days when the vital statistics of an aircraft consisted of a couple of provocative poses on the tarmac?

There are on the market now plans for five amateur aircraft. Soon there is to be a two-seat cabin aircraft with folding wings for the amateur to build. Are they *all* ugly and over-rated? If Mr. Cooper can afford to be choosy about the looks of an amateur aircraft then, with due respect, he should not bother with them, but invest in his much-vaunted Chipmunk.

The Government seems to be a favourite scapegoat. Rather than stand barking outside the door, let the "enthusiasts" stop moaning and get out the glue-pot and gimp pins.

Things are not as bad as Mr. Cooper imagines. Furthermore, there are those among us who would give a lot to be let loose with the ugliest aircraft imaginable—provided that it was cheap and easy to fly.

Bembridge, I.o.W. ARTHUR W. J. G. ORD-HUME,
Member, Popular Flying Association.

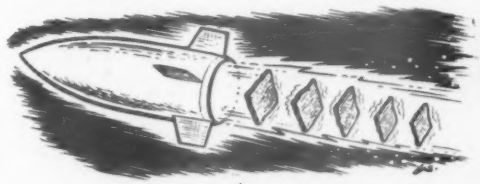
Groundabout

The M.H.D.O.I.F. has been awarded to Plt. Off. —— for Making Little of It. An F.A.A. pilot, landing at an R.A.F. grass airfield where Plt. Off. —— was the Flying Control Officer on duty, was forced to ignore the white "Tee" in the signals area and to land properly into wind as indicated by the windsock, the difference being some 120°. On apologizing to Plt. Off. —— for this breach of order, he received the reply: "That's all right, old boy, we've just had the 'Tee' repainted and it's been left like that to dry." *From Tee Emm, 1943.*

*

Using their Loaf. There's news that the Americans are trying a form of yeast in one of their rocket fuels. I wish I could think of some bright remark about self-raising satellites.

(Note for Overseas Members of the Friends of Wren Society; "Loaf" comes from Cockney rhyming slang "Loaf of Bread" or "Head." No connection with "Casting their bread upon the waters.")



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Unfair to G.E.s. A Mexican newspaper refers to the brisk use being made of a Britannia by Aeronaves and mentions that it only had to be taken off service for scheduled maintenance every 100 years. Pressed for confirmation, Bristol's admitted that it is actually a longer period than they recommend—at the moment, anyway.

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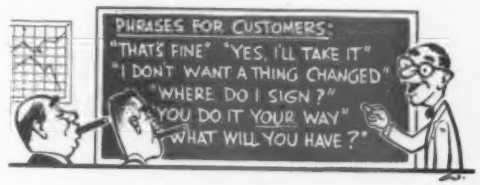
Always Right. Among the responsibilities of Northrop Aircraft's director Lee H. Smith is one headed "Customer Training." We know what they mean but in these competitive times it does evoke a wishful thought or two.


PHRASES FOR CUSTOMERS:
"THAT'S FINE" "YES, I'LL TAKE IT"
"I DON'T WANT A THING CHANGED"
"WHERE DO I SIGN?"
"YOU DO IT YOUR WAY"
"WHAT WILL YOU HAVE?"

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The above sentiment recalls a reply I heard in a bar when an aircraft company executive was asked about one of his directors: "He's just back from a world tour, biting his sunburned fingernails."

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And *that* reminds me of the export-or-bust character of whom it is alleged that he would sell his grandmother abroad if she had wings.

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Slow-Slow-Quick-Quick-Slow. These West Country readers really are pretty smart. Mr. R. J. Parkhouse, of Bristol, has sent me this note: "Why have the R.A.F. named their troop-carrying exercise 'Quick-step'? Is it because they are using two Beverleys, two Comets and one Beverley?"

by Gremlin

NOTES AND EVENTS

FIRE FIGHTERS.—Six Pyrene Mk. VI heavy-duty airfield crash tenders for the R.C.A.F. form part of a large export order worth Canadian $1½ million. Powered by a Rolls-Royce engine of 238 b.h.p., these tenders can cross rough or boggy ground at high speed. Each can project foam at the rate of 10,360 gal. in 2 min.

SPACE AGE CONFERENCE.—H.R.H. The Duke of Edinburgh will address a youth conference on space travel at the Royal Festival Hall on April 14. The conference is being organized by the Air League; its chairman will be the C.A.S., Marshal of the R.A.F., Sir Dermot Boyle. Other speakers will come from English Electric, de Havilland Propellers, the R.A.E. and Rolls-Royce. They will discuss British plans for space travel and the construction, control and propulsion of interplanetary rockets.

AVON FILM.—Now available for public showing is "The Avon Turbojet Engine," a 20-min. Rolls-Royce training film. It was made at the company's aero-engine school at Derby in 1954 but since then has been classified as secret. It surveys the basic principles of the jet engine and the differences between centrifugal-flow and axial-flow types. The Avon engine, its components and systems, are described in detail. Both 35-mm. and 16-mm. copies of the film can be borrowed, free of charge, from the Sound-Services Library, 269 Kingston Road, London, S.W.19.

Books on Nuclear Reaction

Recently published by Temple Press Limited, in association with its monthly journal *Nuclear Engineering*, are three monographs bound with card covers and measuring 5½ in. by 8½ in. No. 1 is entitled "Elementary Nuclear Physics" (68 pp.), by W. K. Mansfield (price 10s. 6d. or 11s. 1d. by post); No. 2, "Nuclear Reactor Theory" (80 pp.), by J. J. Syrett (price 12s. 6d. or 13s. 2d. by post), and No. 3 is "Reactor Heat Transfer" (68 pp.), by W. B. Hall (price 10s. 6d. or 11s. 1d. by post). These books can be obtained from all booksellers and bookstalls or direct from Temple Press Limited, Bowling Green Lane, London, E.C.1.

COOLING FANS.—A special fan for cooling the radio equipment in the Comet 4 has been designed, tested, manufactured and delivered in eight weeks by the Airscrew Co. and Jicwood, Ltd., of Weybridge, Surrey. Two Airscrew fans have been ordered for the Westland Wessex. They are high-output fans which cool oil for the engine and rotor-gear box. A third fan has been designed to circulate air for cabin heating. The company is now working on the design of high-performance miniature fans which could be used for cooling electronic equipment in inter-continental rockets and space vehicles.

NEW NAME.—On March 1 the name of the Radio Communication and Electronic Engineering Association will be changed to "The Electronic Engineering Association." Mr. F. S. Mockford, of Marconi's Wireless Telegraph Co., Ltd., has been re-elected chairman.

CELLULOID INSTRUCTION.—"Chelsea College" is the title of a new 10-min. film describing the courses of the Chelsea College of Aeronautical and Automobile Engineering. The College has over 400 students, one-seventh of whom are concerned with aeronautics. More than 15,000 students have passed through the College since it was founded in 1924.

EXPORT TO PAKISTAN.—Heenan and Froude, Ltd., of Worcester, is to supply a Heenan torque reactor stand to Pakistan International Airlines for installation at Karachi Airport. The plant will be used initially for after-overhaul testing the Rolls-Royce Dart engines of the three Vickers Viscounts which P.I.A. have on order. A cable-suspended hangar stand supplied to Air India International by the company for testing piston engines is now in operation at Santa Cruz airport, Bombay.

MOSCOW START.—The first consignment of Dagenite aircraft batteries made by Peto and Radford for use by B.E.A. at Moscow airport was flown out in a Viscount on February 18. The equipment consists of six 12-ECM.13 cell blocks in parallel and, in series with that bank, a further bank of four parallel sections, each of three EP.19 cells. The 30-V. supply provided is made up of 15 Ah at 10-hr. rate plus 6-V. 220 Ah at 10-hr. rate.

AIRCRAFT STARTERS.—The Mk. 2a low-pressure air starter designed by Blackburn and General Aircraft, Ltd., is now being produced by a subsidiary, Jowett Cars, Ltd. The new trolley incorporates several modifications, the most noticeable of which is that the hose in one length is now carried on top of the trolley already connected to the engine. One such trolley has been delivered to Blackburn's aircraft division for starting the D.H. Gyron Junior engines of the NA.39 strike aircraft.

Aviation Calendar

March 1.—British Interplanetary Society lecture, "The Guidance and Control of Long-range Vehicles," by Professor G. A. Whitfield, B.Sc., F.Inst.P., A.M.I.E.E., A.F.R.Ae.S., in the Tudor Room, Caxton Hall, **London,** S.W.1, at 18.00 hrs.

March 4.—R.Ae.S. Luton Branch lecture, "Ultra-sonic Testing of Light Alloys," by J. Crowther, in the Napier senior staff canteen, **Luton Airport,** at 18.15 hrs.

March 4.—R.Ae.S London Airport Branch second annual dinner.

March 5.—11th Louis Blériot Lecture, "The Future of Aeronautical Research," by Professor W. J. Duncan, C.B.E., D.Sc., F.R.S., F.R.Ae.S., at l'Aéro-Club de France, 6 Rue Galilée, **Paris,** 16e, at 17.00 hrs. (local time).

March 7.—Helic. Assn. of Gt. Britain lecture, "Some Ways of Obtaining an Integrated Aircraft," by Dr. D. Küchemann, F.R.Ae.S (R.A.E., Farnborough), in the R.Ae.S. library, 4 Hamilton Place, **London,** W.1, at 18.00 hrs.

March 11.—Inst. of Civil Engineers lecture, "Akrotiri, Airfield, Cyprus," by J. Ellis, at Gt. George St., **London,** S.W.1. at 17.30 hrs.

March 11.—R.Ae.S. Boscombe Down Branch lecture, "Navigation and the Air Traffic Control Problem," by D. O. Fraser, F.I.N., A.R.Ae.S., in the lecture hall, A. and A.E.E., **Boscombe Down,** Hants, at 17.45 hrs.

March 12.—R.Ae.S. Weybridge Branch lecture (joint meeting with the Inst. Mech. Engineers, Southern Branch), "Aircraft Production—Present and Future," by S. P. Woodley, M.B.E. (general manager, Supermarine) at the Apprentice Training School, Vickers - Armstrongs (Aircraft), Ltd., **Weybridge,** at 18.00 hrs.

March 12.—R.Ae.S. Southampton Branch lecture, "Future Developments with Satellite Rockets," by Dr. L. R. Shepherd, B.Sc., A.M.Inst.P., in the Inst. of Education, **University of Southampton,** at 19.00 hrs.

March 13.—R.Ae.S. main lecture, at Christchurch Branch, "The Problems Arising from the Use of Deflected Engine Thrust for Reducing Aircraft Approach Speeds," by P. F. Ashwood, A.F.R.Ae.S., and D. Lean, A.F.R.Ae.S., at **Bournemouth** Technical College at 19.30 hrs.

March 14.—British Gliding Association annual ball at Londonderry House, 19 Park Lane, **London,** W.1, 20.30 hrs.-02.00 hrs.

March 17.—R.Ae.S. Bristol Branch, Barnwell Memorial Lecture. "The Economy of Structures," by Sir Alfred Pugsley, in the conference room, Bristol Aircraft, Ltd., Filton House, **Bristol,** at 18.00 hrs.

March 19.—R.Ae.S Leicester Branch lecture, "Aircraft Photography, 1913-57," by John Yoxall, in the lecture theatre, **Loughborough College,** at 18.45 hrs.

Company Notices

NEW COMPANIES

Aero Motors (J. Watson), Ltd. (598,515).—Private co. Reg. Feb. 7. Cap. £30,000 in £1 shares. Directors: James Watson (managing director), Olive K. Watson and Marjorie Watson, all of Silverdene, Woolsington Park, Newcastle on Tyne; and James B. Watson and Grace Watson, both of Silvergates, Woolsington Park, Newcastle on Tyne. Sec.: J. B. Watson. Solrs.: Waller and Houseman, Newcastle on Tyne. Reg. off.: Two Ball Lonnen, Newcastle on Tyne.

Aircraft Manufacturing Co., Ltd. (598,510).—Private co. Reg. Feb. 6. Cap. £100 in £1 shs. Objects: To carry on the business of aircraft manufacturers in all its branches, etc. Subscribers (each with one sh.): F. E. Farres and A. T. Ruby, clerks, both of 59-67 Gresham St., London, E.C.2. First directors to be appointed by subscribers. Solrs.: Linklaters and Paines, 59-67 Gresham St., London, E.C.2.

OVERSEAS COMPANY

Eros Airline Co., Ltd. (4,673).—Particulars filed Feb. 10, 1958, pursuant to Section 407 of the Companies Act, 1948. Cap.: £50,000 in 100,000 "A" shs. of 50 Mils and 45,000 "B" shs. of £1. Reg. in The Colony of Cyprus on December 12, 1957, to operate and maintain air transport services, etc. British address: 36 Hampstead Rd., London, N.W.1. Alexander Homatus, of 11 Sandringham Rd., London, N.22, is authorized to accept service of process and notices. Directors: Alexander Homatus, 11 Sandringham Rd., London, N.22; Ioannou Costakis, Nicosia (directors of Cyprus Travel (London), Ltd.); Nicos M. Hadji Gavriel, Nicosia.

New Patent

APPLICATION ACCEPTED

792,993.—Grose, F. J.—"Aircraft."—May 9, 1956 (May 10, 1955).

Application open to public inspection on April 9, 1958; opposition period expires on July 9, 1958.